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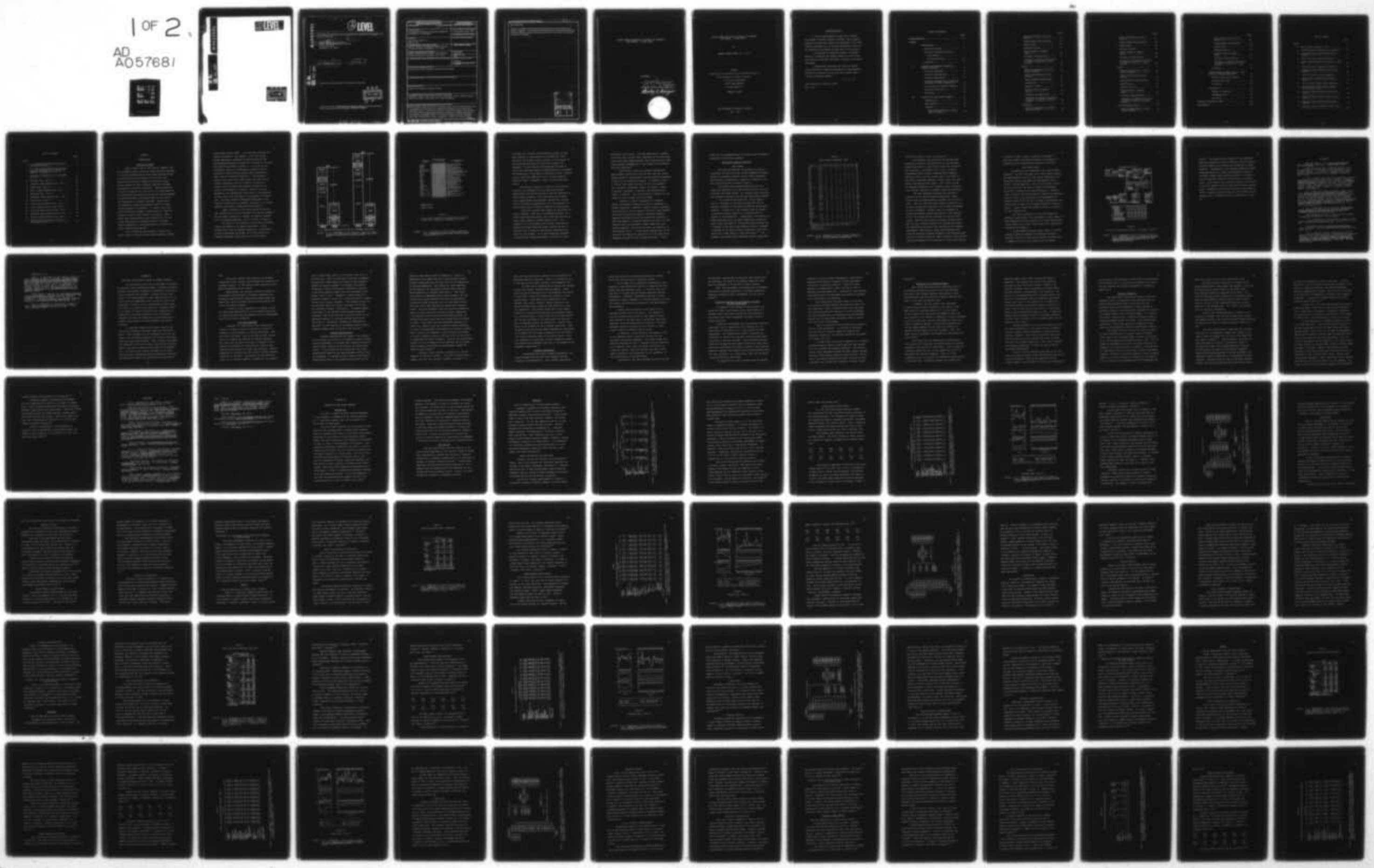

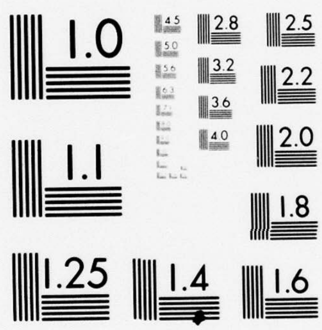

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6 UNITED STATES RELIANCE ON IMPORTS OF MINERALS AND METALS: A CASE STUDY.

Herman

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Recent events such as the Arab oil embargo and rising commodity prices have caused public concern over the continued availability of raw materials at reasonable prices. This thesis focuses on answering whether raw materials are subject to collusion among producing countries to withhold supplies or raise prices and whether there is a physical shortage of these materials. A case study of chromium, cobalt, manganese, nickel and platinum-group (cont)

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metals is conducted considering the political and economic aspects of mineral supplies. The results indicate that there is no physical shortage and that collusion among producing countries to raise prices or restrict supplies is not likely.

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UNITED STATES RELIANCE ON IMPORTS OF MINERALS AND METALS: A CASE STUDY

APPROVED:

Stanley A. Arbingast

UNITED STATES RELIANCE ON IMPORTS OF MINERALS
AND METALS: A CASE STUDY

by

HERBERT HERMAN WORFF, JR., B.B.A.

THESIS

Presented to the Faculty of the Graduate School of

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H. H. W., Jr.

The University of Texas at Austin

May, 1978

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CHAPTER I

INTRODUCTION

Scope and Purpose

Recent events, such as the Arab oil embargo, and the worldwide economic boom have served as stark reminders to the United States and the other industrialized nations of the world that interruptions in the flow of raw materials and spiraling commodity prices could place serious burdens on their economies, political systems, and relations with other countries.[1] The political use of economic resources as set forth by the Organization of Petroleum Exporting Countries has put into motion attempts at worldwide economic realignment based on the control and distribution of natural resources. Additionally, the competition among the consuming nations for these limited supplies is increasing. In almost every case, the United States consumes a greater share of these raw materials than any other nation in the world. These events have caused growing public concern over the continued availability at reasonable prices of mineral imports necessary for the United States to maintain its highly industrialized society.

This concern has been generally focused on an energy crisis, but there exists another possible minerals

crisis that could be worse. It is one that involves the non-fuel minerals.[2] For example, in 1977 the United States imported an estimated $63 billion worth of raw and processed materials of which $16.9 billion was for non-fuel minerals as shown in Figure 1. In a study by the President's Council on International Economic Policy, nineteen of these non-fuel minerals were considered as being critical industrial materials.[3] The Strategic Studies Institute of the United States Army War College recently published a series of reports in which the authors view the current raw materials situation as a possible new dimension of conflict, short of military aggression, but exasperating other areas of international friction that could contribute to the outbreak of hostilities. The basic research memorandum establishes a high relative vulnerability to economic, political, or military pressures for eleven of these non-fuel minerals.[4]

Import reliances on the major portion of the non-fuel minerals has been over 50 percent for several decades.[5] The net import reliance as a percent of apparent consumption for selected materials in 1977 is shown in Figure 2.

The focus of the research in this paper is directed toward the answers to two general questions: are we passing from an era of abundant supplies of raw materials to one of persistent shortages, and to what extent are consuming countries, particularly the United States,

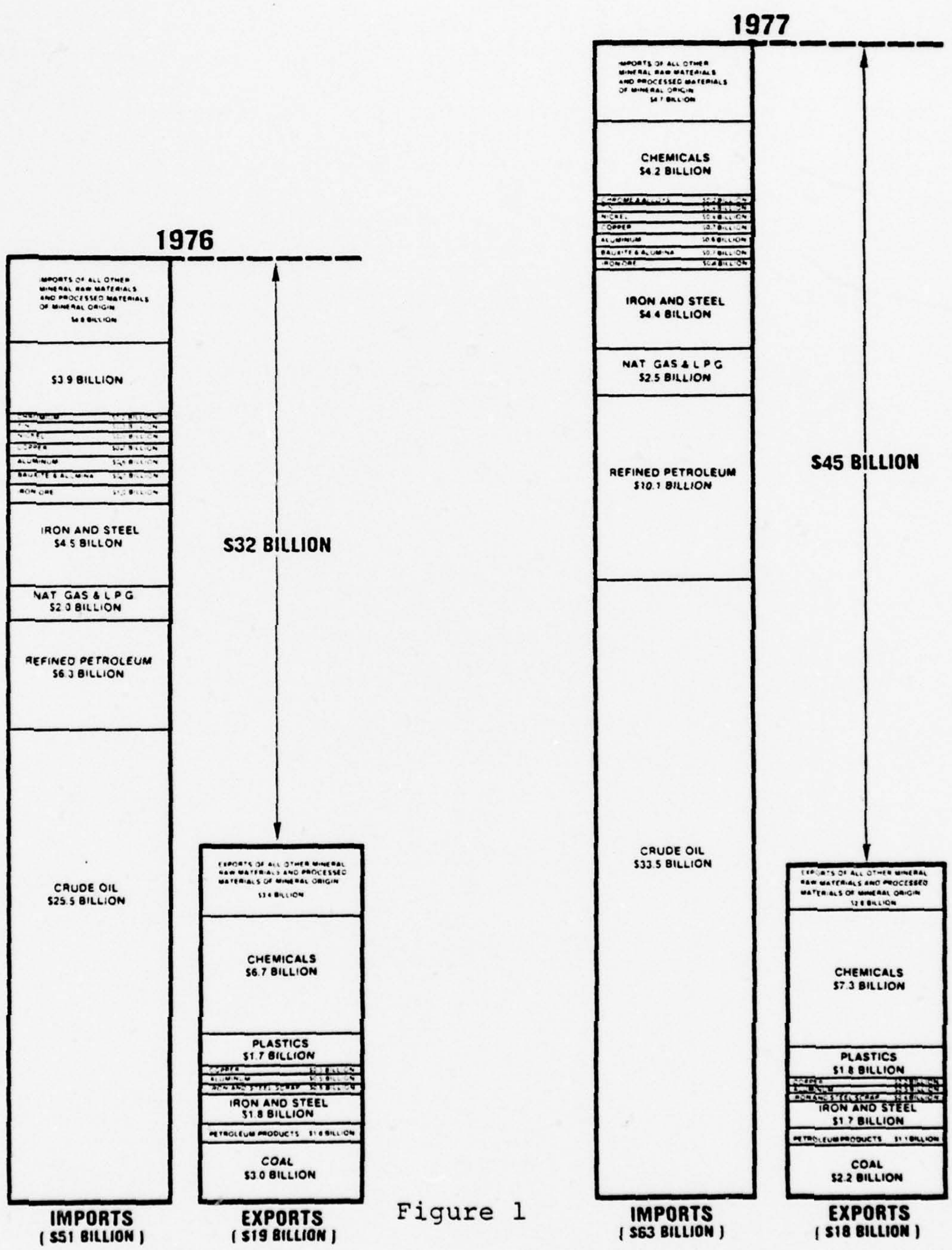


Figure 1

U. S. Imports and Exports of Raw and Processed Materials

Source: U. S., Department of the Interior, Bureau of Mines, _Minerals and Materials/A Monthly Survey_ (June 1977), p. 8.

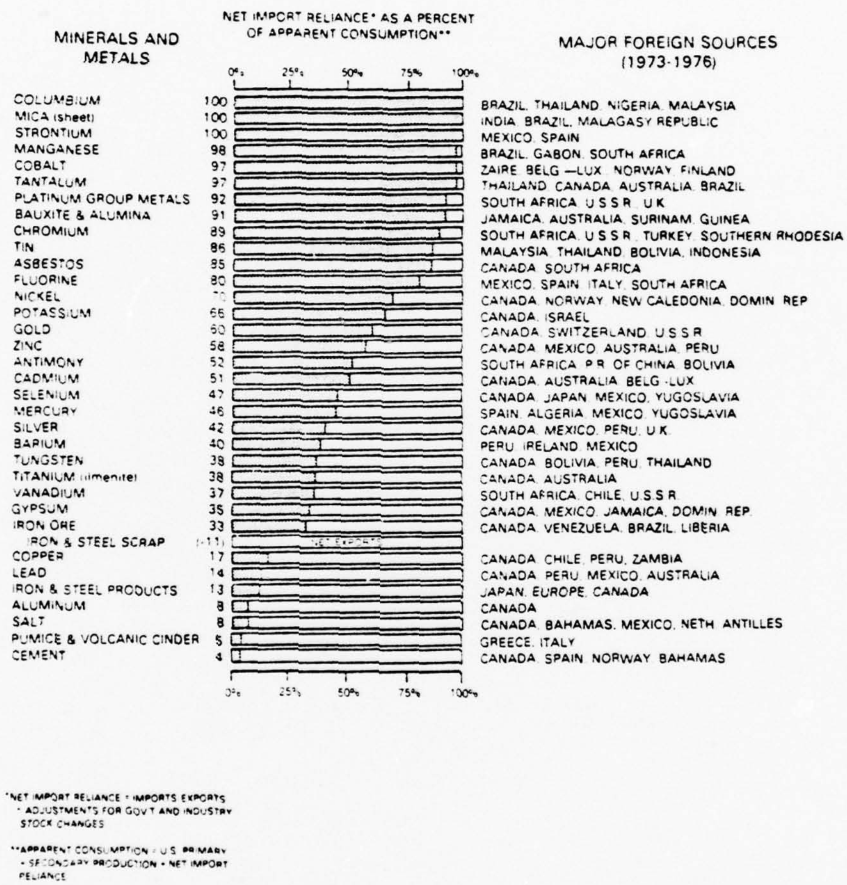


Figure 2

U. S. Net Import Reliance of Selected Minerals and Metals as a Percent of Consumption in 1977

SOURCE: U. S., Department of the Interior, Bureau of Mines, <u>Minerals and Materials/A Monthly Survey</u> (January 1978), p. 6.

vulnerable to collusion among producing nations to withhold supplies or raise prices of raw materials? Both political and economic issues relating to the security of the continued availability of non-fuel minerals are addressed. Current policies and possible solutions to insure the sustained supply of these minerals are discussed. The methodology of this paper is empirical library research using a case study approach on five non-fuel minerals: chromium, cobalt, manganese, nickel, and platinum-group metals.

The factors important in assessing this minerals situation are addressed for each case study mineral. These factors include the mineral's uses and importance in United States industry, areal distribution and production, supply-demand relationships, substitutes, economic factors, strategic considerations, and the potential for cartel-like action to restrict supplies or raise prices.

These five minerals were chosen for this study for several reasons. They are all considered essential to a highly industrialized society and in some way are used in nearly every element of modern American life. For example, it is not possible under current technology to produce high grade stainless steels without the use of chromium, nor is there any satisfactory substitute for cobalt in tool steels. It is not economically possible to produce steel without manganese, and nickel is used

extensively as an alloy. Platinum-group metals, although a low bulk item, reflect their importance in the relatively high prices they command because their characteristics make them uniquely indispensible in the chemical and petroleum refining industries.[6]

Collectively, these five minerals represented approximately one-third of the 1973 net value for United States imports of the nineteen non-fuel minerals considered critical by the President's Council. As shown in Figure 2, the 1977 net import reliance for the five minerals was: chromium, 89 percent; cobalt, 97 percent; nickel, 70 percent; manganese, 98 percent; and platinum-group metals, 92 percent. The high reliance on imports for the supply of each of these can be explained.

There are critical inadequacies of domestic mineral availability despite the nation's abundance of mineral resources. Therefore, domestic mineral consumers must continue to rely on imports for one of three reasons: the United States has no domestic reserves; domestic deposits are known and used, but production capacity is less than demand; or domestic deposits are known, but the minerals cannot be produced at costs competitive with foreign supplies. The latter has been, and generally is the dominant factor. It contributes substantially to the status of the other two, particularly to the first since reserves are based on their economic recovery.[7] Thus,

these five are representative of the more serious problems associated with non-fuel minerals.

Overview of Mineral Situation

World Scene

The areal distribution of minerals is irregular throughout the world with each nation possessing different amounts of different minerals, and no nation possessing the minerals or quantities of minerals it requires to be fully self-sufficient as shown in Table 1.

The current world supply-demand situation for industrial materials can be characterized by dividing the countries into three groups: the industrialized countries, the communist countries, and the less developed countries.

The industrialized countries control approximately 86 percent of the world economy and are the greatest consumers of the natural resources, particularly minerals. Collectively, they consume nearly 90 percent of the world mineral output, but contribute only 66 percent to that production. Consequently, this results in these countries having to import substantial amounts of fuels, ores, and metals.[8] The United States accounts for 27 percent of the world gross domestic product, consumes 30 percent of the world's mineral production, and contributes only a small amount to the world output.[9] For example, the United States estimated minerals trade defi-

Table 1

World Mineral Reserves, 1974[1]

COMMODITY	UNITS	UNITED STATES	OTHER NORTH AMERICA	SOUTH AMERICA	EUROPE	AFRICA	ASIA	OCEANIA	WORLD TOTAL
ALUMINUM	MILLION S.T.	10	270	760	300	1,270	200	1,010	3,840
ANTIMONY	THOUSAND S.T.	100	295	490	560	320	2,650	150	4,565
ARSENIC	THOUSAND S.T.	800	500	1,000	500	500	300	200	3,800
BARIUM	MILLION S.T.	35	5	6	25	10	16	3	100
BERYLLIUM	THOUSAND S.T.	28	-	162	67	59	71	12	419
BISMUTH	MILLION LB	26	17	13	15	1	59	-	131
BORON	MILLION S.T.	20	-	10	20	-	30	-	80
BROMINE		A	A	A	A	A	A	A	A
CADMIUM	THOUSAND S.T.	180	125	55	190	40	100	140	830
CESIUM	MILLION LB	-	70	-	-	16	-	-	86
CHLORINE		A	A	A	A	A	A	A	A
CHROMIUM	MILLION S.T.	-	-	-	13	560	4	-	577
COBALT	MILLION LB	-	1,130	-	500	2,294	-	1,480	5,404
COLUMBIUM	BILLION LB	-	2	18	2	2	-	-	24
COPPER	MILLION S.T.	90	60	130	60	60	30	20	450
FLUORINE	MILLION S.T.	3	8	2	11	3	5	(2)	38
GALLIUM	MILLION KG	1	7	4	9	45	3	41	110
GERMANIUM	THOUSAND LB	900	300	300	800	900	600	200	4,000
GOLD	MILLION T.OZ	120	60	21	206	850	35	28	1,320
HAFNIUM		A	A	A	A	A	A	A	A
INDIUM	MILLION T.OZ	10	13	4	11	3	4	4	49
IODINE	MILLION LB	530	-	800	410	-	4,010	-	5,750
IRON ORE	BILLION S.T.	4	12	20	40	3	11	10	100
LEAD	MILLION S.T.	59	25	6	25	5	27	18	165
LITHIUM	THOUSAND S.T.	327	100	10	201	100	3	3	744
MAGNESIUM		A	A	A	A	A	A	A	A
MANGANESE	MILLION S.T.	-	2	44	755	1,005	47	160	2,013
MERCURY	THOUSAND FL	450	370	30	3,425	30	625	-	4,930
MOLYBDENUM	BILLION LB	6	2	2	2	(2)	1	(2)	13
NICKEL	MILLION S.T.	(2)	10	5	5	1	6	32	60
NITROGEN		A	A	A	A	A	A	A	A
PALLADIUM	MILLION T.OZ	(2)	4	-	-	100	90	-	194
PLATINUM	MILLION T.OZ	(2)	4	(2)	-	248	45	-	297
RARE EARTHS & YTTRIUM	THOUSAND S.T.	5,054	252	353	512	70	1,122	406	7,769
RHENIUM	THOUSAND LB	2,680	410	1,520	900	2	8	-	5,340
RHODIUM	MILLION T.OZ	(2)	(2)	-	-	14	3	-	17
RUBIDIUM	THOUSAND LB	-	1,300	-	-	800	-	-	2,100
SCANDIUM	THOUSAND KG	228	163	-	48	235	-	96	770
SELENIUM	MILLION LB	77	52	36	51	51	26	17	370
SILICON		A	A	A	A	A	A	A	A
SILVER	MILLION T.OZ	1,500	1,590	630	2,000	50	25	205	6,000
STRONTIUM	THOUSAND S.T.	-	1,000	20	2,420	-	60	-	3,500
SULFUR	MILLION L.T.	230	505	30	495	20	695	25	2,000
TANTALUM	MILLION LB	-	7	8	11	100	18	5	149
TELLURIUM	MILLION LB	18	12	22	12	12	7	4	87
THALLIUM	THOUSAND LB	150	160	50	140	40	50	50	640
THORIUM	THOUSAND S.T.	140	230	70	40	40	220	40	780
TIN	THOUSAND L.T.	42	26	1,591	911	705	6,515	330	10,120
TITANIUM	MILLION S.T.	32	57	69	43	23	132	20	376
TUNGSTEN	MILLION LB	238	480	130	376	23	2,600	77	3,924
VANADIUM	THOUSAND S.T.	115	-	250	8,075	2,000	100	150	10,690
ZINC	MILLION S.T.	50	43	18	54	16	46	23	260
ZIRCONIUM	THOUSAND S.T.	6,000	1,000	1,000	3,000	2,000	2,000	7,000	22,000
ASBESTOS	MILLION S.T.	9	56	5	52	22	7	9	160
CLAYS		A	A	A	A	A	A	A	A
CORUNDUM		-	-	-	A	A	A	-	A
DIATOMITE	MILLION S.T.	600	-	70	1,330	-	-	-	2,000
FELDSPAR	MILLION S.T.	600	110	40	100	40	90	10	990
GARNET	THOUSAND S.T.	700	-	10	500	1,000	10	10	2,230
GRAPHITE	MILLION S.T.	(2)	1	(2)	4	1	4	(2)	10
GYPSUM	MILLION S.T.	350	520	40	900	80	100	60	2,050
KYANITE	MILLION S.T.	30	10	-	25	10	25	(2)	100
LIME		A	A	A	A	A	A	A	A
MICA-SCRAP & FLAKE		A	A	A	A	A	A	A	A
MICA-SHEET	MILLION LB	(2)	-	2	-	4	27	-	33
PERLITE	MILLION S.T.	200	5	-	765	-	20	10	1,000
PHOSPHATE ROCK	MILLION S.T.	2,500	2	30	830	12,840	340	1,120	17,712
POTASH	MILLION S.T.	200	5,000	10	5,515	20	245	10	11,000
PUMICE	MILLION S.T.	1,250	50	15	650	30	40	30	2,065
SALT		A	A	A	A	A	A	A	A
SAND & GRAVEL		A	A	A	A	A	A	A	A
SODA ASH		A	A	A	A	A	A	A	A
STONE-CRUSHED		A	A	A	A	A	A	A	A
STONE-DIMENSION		A	A	A	A	A	A	A	A
TALC	MILLION S.T.	150	10	5	60	5	90	10	330
VERMICULITE	MILLION S.T.	100	-	5	5	75	5	-	190
ANTHRACITE	MILLION S.T.	3,500	-	6	3,826	30	288	-	7,650
BITUMINOUS COAL & LIGNITE		A	A	A	A	A	A	A	A
NATURAL GAS	TRILLION C.F.	237	68	65	876	196	633	71	2,146
PEAT		A	A	-	A	-	A	-	A
PETROLEUM	BILLION BBL	3/ 47	25	24	112	68	448	2	4/ 720
SHALE OIL	BILLION BBL	-	-	-	30	-	20	-	50
URANIUM	THOUSAND S.T.	5/ 267	204	-	61	294	-	240	1,066
ARGON		A	A	A	A	A	A	A	A
HELIUM	BILLION C.F.	153	1	-	-	-	-	-	154
HYDROGEN		A	A	A	A	A	A	A	A
OXYGEN		A	A	A	A	A	A	A	A

A ADEQUATE

1/ IDENTIFIED RESOURCES ARE SPECIFIC BODIES OF MINERAL-BEARING MATERIAL WHOSE LOCATION, QUALITY, AND QUANTITY ARE KNOWN FROM GEOLOGIC EVIDENCE SUPPORTED BY ENGINEERING MEASUREMENTS WITH RESPECT TO THE DEMONSTRATED CATEGORY, AND INCLUDE RESERVES AND SUBECONOMIC RESOURCES. THE RESERVE IS THAT PORTION OF THE IDENTIFIED RESOURCE FROM WHICH A USABLE MINERAL OR ENERGY COMMODITY CAN BE ECONOMICALLY AND LEGALLY EXTRACTED AT THE TIME OF DETERMINATION.

2/ LESS THAN ONE UNIT.

3/ INCLUDES NATURAL GAS LIQUIDS.

4/ REVISED IN 1975 TO 665 BILLION BARRELS.

5/ 780,000 TONS AT $30/LB (FEDERAL ENERGY RESOURCES COUNCIL, 6/15/76).

SOURCE: U. S., Department of the Interior, Bureau of Mines, Mineral Trends and Forecasts (1976), p. 10.

cit was $45 billion in 1977 (see Figure 1).

The communist countries have for the most part developed a practical self-sufficiency in all minerals except fuels, which is particularly true with the Soviet Bloc countries. At present, the U.S.S.R. is making considerable effort toward increasing their domestic production and at gaining control over a large part of the world's resources located in Africa, Asia, and Latin America through political means. Also, there has been an increased interest by the communist group in trading their mineral resources for western goods and technology.

The less developed countries are substantial producers of the world's mineral commodities. Their current share is approximately 30 percent of the world's total. Thus far, they have been unable to make full use of their raw materials because of the limited development of their industries. However, they are attempting to finance development through the export of their commodities to the industrialized countries for cash and technology. They are also trying to attract foreign investment in their countries because the revenues from these raw materials have proved to be insufficient for adequate development. Additionally, these less developed countries are exerting increased pressure on the industrialized nations for higher prices for their resources, lower tariffs, and more processing of raw materials in their own countries

in order for them to enjoy a greater value added.[10] This will result in increased burdens on the balance of payments for the industrialized nations of the world.

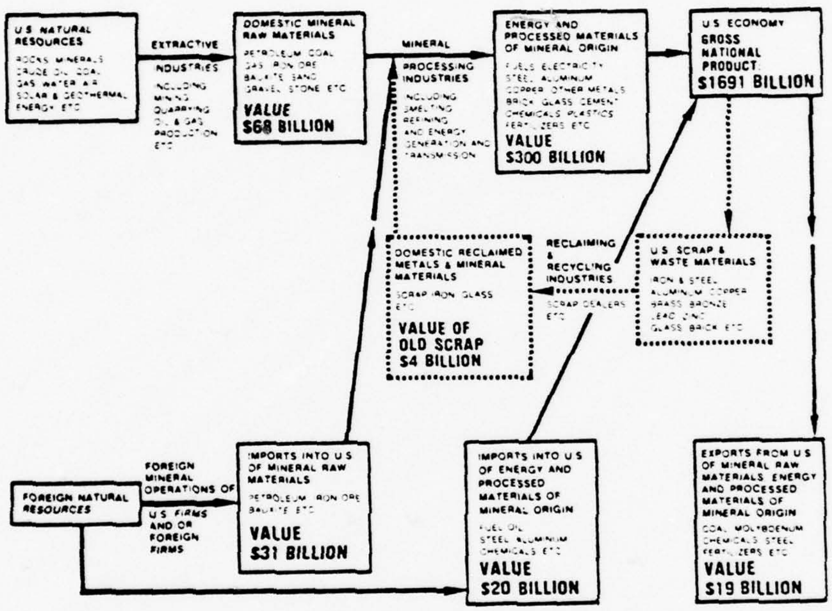
The United States

Minerals are very important in the United States economy.[11] In 1976, the total use of new mineral supplies was approximately 4 billion tons, which translates to an annual per capita requirement of approximately 40,000 pounds. For the same year, with a gross national product of $1,691 billion, the value of energy and processed materials of mineral origin was $300 billion. Domestic input, valued at $68 billion worth of mineral raw materials and $4 billion in old scrap had to be supplemented by imports valued at $31 billion of mineral raw materials and $20 billion of energy and processed materials of mineral origin. Figure 3 shows the economic activity of minerals for 1971 through 1976.

The mineral reserves of the United States are adequate in some cases, but questionable in many others.[12] When compared with world reserves, the United States holds a small share of the total, particularly with consumption considered (see Table 1).

As the domestic economy grows, there is a corresponding increase in demand for industrial materials. Likewise, the rest of the world's economy is growing and it appears to be at a rate greater than the United

(ESTIMATED VALUES FOR 1976)



ECONOMIC ACTIVITY'	1971	1972	1973	1974	1975	1976
DOMESTIC MINERALS RAW MATERIALS	31	32	37	55	63	68
RECLAIMED MATERIALS	2	2	4	4	3	4
IMPORTED MINERALS RAW MATERIALS	4	4	7	20	21	31
ENERGY AND PROCESSED MATERIALS	6	10	12	22	19	20
DOMESTIC ENERGY & PROCESSED MATERIAL OF MINERAL ORIGIN	145	170	200	255	265	300
U S GROSS NATIONAL PRODUCT	1063	1171	1306	1415	1516	1691
EXPORTS OF MINERAL RAW MATERIAL ENERGY AND PROCESSED MATERIALS	7	8	11	18	18	19

' ESTIMATED IN BILLIONS OF DOLLARS

Figure 3

Activity of Minerals in The U. S. Economy, 1971-76.

SOURCE: U. S., Department of the Interior, Bureau of Mines, Minerals in the U. S. Economy: Ten-Year Supply-Demand Profiles for Mineral and Fuel Commodities (1966-75), p. 3.

States.[13] This growing world demand for the industrial materials necessary to sustain economic growth is placing serious burdens on the supplies and production of these materials. Consequently, the increased competition among consuming nations for these limited supplies creates a favorable climate among producing nations to withhold or restrict important materials for political or economic gains. This current world minerals situation could result in serious problems for the United States mineral requirements. Therefore, the situation must be investigated in order to assess the extent that the United States will be affected and to determine possible alternatives if need be.

FOOTNOTES

[1]See Paul Rogers, ed., Future Resources and World Development (New York: Plenum Press, 1976).

[2]Serious concern over a possible mineral crisis was expressed in an interview by the Secretary of the Interior, Rogers C. B. Morton. "A Minerals Crisis Would Be Worse Than The Energy Crisis," Forbes (15 February 1974): 48-9.

[3] U. S., Executive Office of the President, Council on International Economic Policy, Special Report: Critical Imported Materials (December 1974). The critical minerals listed are aluminum, chromium, platinum, iron ore, nickel, natural rubber, manganese, zinc, tin, titanium, cobalt, mercury, tungsten, lead, columbium, vanadium, fluorspar, copper, and phosphate.

[4]U. S. Army War College, Strategic Studies Institute, Materials And The New Dimensions of Conflict, revised ed., by Alwyn H. King and John R. Cameron, Military Issues Research Memorandum 74-10-R (Carlisle Barracks, PA: U. S. Army War College, 1974); and U. S. Army War College, Strategic Studies Institute, Materials Vulnerability of the United States - An Update, by Alwyn H. King, Special Report ACN 77020 (Carlisle Barracks, PA: U. S. Army War College, 1977).

[5]U. S., Department of the Interior, Annual Report of the Secretary of the Interior And The Mining And Minerals Policy Act of 1970, for 1977, p. 24.

[6]The specifics on each of the case study minerals is presented in Chapter II of this paper.

[7]U. S., Department of the Interior, Bureau of Mines, Draft of Strategic and Tactical Plan (January 1976), p. II-23.

[8]Alexander Sutulov, Minerals in World Affairs (Salt Lake City: The University of Utah Printing Services, 1972), p. 35.

[9]U. S., Congress, Senate, Committee on Interior Insular Affairs, Hearings before a Subcommittee on Minerals, Materials, and Fuels, The Final Report of the National Commission on Materials Policy 'Material Needs and the Environment: Today and Tomorrow.' 93rd Cong., 1st sess., 1973, p. 2-24.

[10]Sutulov, p. 35.

[11]See U. S., Department of the Interior, Bureau of Mines, Minerals in the U. S. Economy: Ten-Year Supply Demand Profiles for Mineral and Fuel Commodities (1965-74); U. S., Department of the Interior, Bureau of Mines, Draft Strategic, p. I-6-10; and U. S., Department of Commerce, Bureau of Census and U. S., Department of the Interior, Bureau of Mines, Raw Materials in the U. S. Economy: 1900-1969, by Vivian Eberle Spencer, Working Paper 35 (1972).

[12]See Eugene N. Cameron, ed., The Mineral Position of the United States, 1975-2000 (Madison, Wisconsin: The University of Wisconsin Press, 1973); and Ralph W. Marsden, ed., Politics, Minerals, and Survival (Madison, Wisconsin: The University of Wisconsin Press, 1975).

[13]U. S., Department of the Interior, Bureau of Mines, Draft of Strategic and Tactical Plan (January 1976), pp. II-8 - II-9.

CHAPTER II

POLITICAL AND ECONOMIC ASPECTS OF MINERAL SUPPLIES

The availability and price of the supply of minerals and metals in the international market is subject to certain political and economic components influenced by the actions of both producers and consumers. Producer actions that result in the interruptions of these supplies can be in the form of political embargoes aimed at altering conflicting ideologies of foreign nations; organizations whose intent is to raise or maintain price levels of a commodity common to the group; or national control of the production and exploitation of natural resources, which is generally intended to prevent the perceived or actual imbalances in economic gains between the host government and foreign interests.

An important aspect of the latter, tainted with political and economic overtones, comes from the recent shift in power between the rich consuming nations and the poorer, less developed countries which contain significant resources within their borders. These countries are demanding sovereignty over their natural resources and a greater share in the wealth through actions short of nationalization. The actions have caused a dilemma for the multinational mining corporations that has resulted in changing the association between the corporation and the govern-

ment.

There are, however, both political and economic limitations to the leverage that producers can administer to consuming nations. In the long-run these delimiters could make the producers the big losers.

Additionally, the cyclical volatility inherent in the economic characteristics of mineral industries will frequently cause short-run imbalances between supply and demand that could ultimately affect the availability and prices of natural resources.

A review of these components is in order, so that the mechanisms responsible for the availability and price of natural resources and the pressures of an interdependent world can be better understood.

Political Embargoes

Embargoes are constraints on the international movement of supplies which are imposed by a country in response to either domestic or foreign conditions. When politically motivated, they are designed to harm, discipline, or influence the behavior of foreign countries. The latter was the case of the Arab oil embargo in 1973, designed to pressure the industrialized countries into changing their position on Middle East policies. However, embargoes of raw materials, particularly non-fuel minerals, generally are unlikely. The objective of the producing nation is to increase revenues; consequently, any restric-

tion in trade could result in an economic loss, even in the short-run. This is particularly true when a commodity accounts for a major share of a country's gross domestic product and export revenues. For example, the mineral industries of Zaire contributed an estimated 33 percent of the gross domestic product and over 90 percent of the export value in 1974.[1] Therefore, a country must have economic strength to carry out a sustained period of embargo without great internal hardship. Such economic muscle and the political desire are partly attributed to the Arab oil producers' success. Additionally, an imposed embargo could result in the affected country seeking supplies elsewhere, such as the case when the Soviet Union cut off manganese supplies to the United States shortly after World War II. Regardless, embargoes can sometimes be disruptive to the supplies of the imposed nation, causing undesired effects both in the short and long run.[2]

Producer Organizations

Producer organizations are formed in the interest of the economic well being of its members, usually through collusive agreements to increase their monopoly profits by fixing prices, dividing up the markets, and restricting output. In the context of this discussion, only those organizations formed by the less developed countries will be considered. It should be noted, however, that similar organizations exist in the industrialized world, but go

under the less ominous name of oligopolies. Cartel is perhaps the most common term for a less developed country producer organization and the best known is the Organization of Petroleum Exporters. The impetus for their formation can be traced to the untenable situation these countries found themselves in following World War II. Even after the effects of independence from colonial powers, the real control over natural resources lay with the multination corporations whose alliances were with the industrialized countries, which were experiencing unparalleled economic growth. The less developed countries also found themselves unable to obtain the price for their primary commodities or raw materials that would match accelerating prices for manufactured goods, which they were neither able to produce or export. This placed the less developed countries in a trade trap, unable to earn the necessary foreign exchanges for their own development from domestic raw material exports. Their situation was temporarily rectified with the upsurge of primary commodity prices in 1973 and 1974, but did little to compensate for years of decline. Finally, the overwhelming success of the oil embargo by Arab producers set the contemporary example and provided the encouragement needed for others to move forward.[3]

Currently, eight minerals, including oil, are the subjects of actions by cartels. The others include bauxite, copper, iron ore, tin, mercury, tungsten, and lead.[4] To

date, none has enjoyed the success of the Organization of Petroleum Exporting Countries. There is an exception, but it was done by one country, Morocco, with phosphate rock.

In order for an organization to achieve such success, certain key economic variables must be present. These would include an association of a few producers who control a large share of the world market with numerous and dispersed buyers. There must be low disparities in the members' cost ratios, reserves, excess capacities, and social discount rates, along with high barriers of entry for competitors. The product should have a high demand growth with a negligible possibility for secondary production and substitutes. Rising prices can not affect demand nor can they encourage to any great extent the development of supplies outside the association. Finally, there should be the absence of major consumer stockpiles. Other variables would include the common awareness of vulnerability of members and the common perception of net collective gain and the effective means of collective action. Also, the cooperation or neutrality of major industrial powers and transnational companies would add to the success of the producers' association.[5]

Economic Nationalism

Dissatisfied with their economic performance, the less developed countries have been demanding greater economic self-determination. This economic nationalism

stems from several very definite objections to foreign capital and the friction it frequently creates.

One of them is the insufficient processing of raw materials, which effectively results in exporting the much needed jobs and additional value, a situation that will keep them in a trade trap and further aggravate relative development. Therefore, considerable pressure is being exerted on foreign investment to integrate operations within the country, and establish programs for semi-manufacturing and processing.

Another strong objection is the total flow of corporate profits out of the country. The argument is that the original capital input by the company is small when compared to the many years of profitable operations, especially after the amortization of capital. The less developed countries perceive this as contrary to their primary objective, internal capital growth.

An objection is also raised on the opposing views on the expansion rate of operations between the host government and foreign companies. The former argues that national interests are hurt if resources are not exploited on an adequate scale, while the latter is reluctant to invest new capital, even with minerals that have a good market, because of the uncertainty in tax treatments, or the possibilities of nationalization.

Additionally, the less developed countries see the

multinational corporations as having too much control over the production and trade of the primary commodities that many are dependent on for the bulk of their exports.

Thus, host governments are increasingly considering intervening in mining operations to influence production schedules, processing plant investments, and the flow of profits.[6]

Corporate Adaptability to Changing Attitudes of Host Governments

In response to the changes in world economic and political order, United States mining corporations have modified their traditional policies of total ownership and control over their investments and capital flows in foreign countries.

Firms have relinquished the long standing corporate requirement that a company have total control over its operations and have gone in on a joint venture with host governments. The companies have found it possible and profitable to operate with the host country holding either a majority or minority interest. This minimizes political risks and provides the much needed financing in some cases. Where host governments are unable to share in the financing, American companies have offered the host participation without cost investment at a future date, after the attractive initial profits have been taken.

In response to the host government seeking maximum

revenues to finance economic development, United States companies have acceded to demands to build processing facilities in some host countries. Firms have found savings in transportation, labor, and energy costs by exporting processed materials. Additionally, most developing countries have less stringent environmental standards, which adds another cost reduction.

Where objections have been raised to long term contractual obligations between the producing nation and the corporation, offers of renegotiation have been made. This should eliminate the feeling by the host government that the multinationals are exercising too much economic control over the main source of exports used to finance the rising cost of development.

Service contracts are yet another policy change to cope with host governments. In contrast to ownership, the firm acts as a service company by supplying the managerial, marketing, and technical skills to the producing country for a fee.

In order that firms protect themselves in a possible unstable producer climate, consortiums have been entered into with European and Japanese companies. This participation, which sometimes includes the host country, spreads the risk, while massing funds for large projects. Politically, any serious dispute which might rise with the host government will involve the interests of several foreign

countries.[7]

Limitations to Producer Leverage

Even though there has been an appreciable gain in the economic and political power of the less developed countries, which produce important raw materials, there are delimiters that will nullify or severely moderate this power in both near and distant terms.

In general, the very reasons that strengthen producer power are also a measure of the limits of such power and can be applied negatively.[8] The key factor is the economic fact that while the demand for most non-fuel minerals is not reduced in proportion to price increases in the very near term, the long term demand in relation to price is generally reduced. The historic experience for tin and copper suggest that the long term reduction in demand more than offsets any price increase. Thus, the total return to producers will become less than before the price change.

The reason for this demand-price relationship is the existence of stockpiles, the possibilities of secondary production, and the rise of substitutes. None of these are currently present for oil, so the example set in 1973 is misleading for non-fuel producers. Also, it is not necessary to have all three of the moderating forces acting at the same time. Stockpiles releases will cushion the

immediate impact except where a protracted threat is perceived. Then releases may not be large enough to mitigate the near term price increase. However, the recycling of scrap, which is carried out for most major non-fuel minerals, is determined by its economics. The pace will be accelerated by price increases whether they are due to the business cycle or induced by other means. Another real threat is the possibility of substitutes. Alternate materials can replace the basic mineral as the source, such as with bauxite and alumina; or the mineral itself, such as aluminum and steel in cans. In addition, industry has historically sought for the most economical material input; therefore, price increases would only add impetus to this search.

Producer leverage will also be limited by the size and areal distribution of the world's mineral resources, which cut across varying aggregations of political and economic interests. There are few exceptions where non-fuel minerals are totally concentrated within the same political and economic ideologies. Also, price increases may stimulate production in areas that were otherwise considered uneconomical.

Finally, mineral producing countries are for the most part totally reliant on the industrialized nations for foreign investment. This is the exploration of the mineral deposit, the evaluation of the mine and formulation

of the project, the provision of risk capital and technology for the construction of the mine and processing facilities, and the technical and financial management of productive operations.[9]

Cyclical Volatility

The instability of the market caused by rapid and sometimes violent fluctuations in the business cycle can cause severe shortages either in the sense that the available supplies are inadequate to satisfy demand at prevailing prices or that sharp price increases are required to constrain demand to the available supply. As a result, the mineral industries will frequently encounter short-run imbalances between supply and demand. This creates sharp fluctuation in output and profits and sometimes prices, which are not necessarily caused by insufficient capacity.

The cause of cyclical volatility comes as a result of three characteristics of mineral supply and demand. First, there is an unresponsiveness of supply in the short-run to price changes once maximum capacity is met. This is termed by economists as low short-run price elasticity of supply or it is said to be price inelastic in the short-run. In other words, as long as the mineral industry has excess capacity, production can quickly respond to price increases. However, it is very difficult to expand with new capacity even at attractive prices because new mine development and

additions to existing facilities take several years.

The short-run price elasticity of demand is the second characteristic, which means that changes in the price of minerals do not affect demand to any great extent. This negligible effect is explained by two facts. The first is that most mineral products are intermediate goods whose ultimate demand is derived from the final product. Usually, the cost of the intermediate material is but a fraction of the finished good. As a result, the consumer price is relatively unaffected.

Second, even though producers can substitute one material for another, the time for changing plant layout, new equipment orders, and retraining workers causes producers to hesitate until they are certain the price change will last.

The third characteristic responsible for cyclical volatility is the substantial impact that changes in the overall level of economic activity have on the demand for most mineral products.[11] This instability is being even more pronounced as a result of the general growth of international trade, the increased mobility of capital, and the growing influence of multinational companies. These multinationals, operating in several economies, have produced a growing integration of the developed countries economies. Business cycles in the United States, Western Europe, and Japan have become almost synchronized without

any effective mechanism to control the cycles. A world-wide boom as in 1972 and 1973 causes great increases in the demand for industrial materials and creates tremendous strains on capacities to produce, that will not be relieved in the short-run if producers are already at near capacity. Conversely, a recession will depress demand and further aggravate market stability.[12]

In addition to the three characteristics of mineral supply and demand, other factors such as private speculation, accumulation and disposal of government stockpiles, and interruptions in production cause shifts, in the supply or demand curve, thus contributing to cyclical volatility.

Private speculation in commodity markets is baffling to most observers. The rational decision would be to buy when prices were low and sell when prices were high, thereby making a profit while at the same time assisting in stabilizing the price of minerals over the business cycle. This is not always the case with speculators. Also, actions by fabricators add to instability. The general idea for them would be to increase their inventory holding during periods of low prices. However, fabricators are often reluctant to hold such stocks during surpluses and rely on being able to buy on fairly short notice. During a prolonged market depression, their inventories will be reduced and they will buy when the market is on the upswing. The buying rush will be for current consumption and stockbuild-

ing, thus doubling the aggravation of instability.[13]

Government stockpile accumulation and disposal will also cause short-run shifts in the supply or demand curve. Most of these stockpiles are created for strategic purposes, particularly the United States. They were created and enlarged during high demand periods, thereby making short-run shortages more severe. Some of the stocks, however, were accumulated and disposed of in a manner that tended to moderate instability.

Finally, interruptions in the production of minerals, such as the Canadian nickel mining strike, the embargo against Rhodesia, or the Angolan Civil War, can shift the supply curve.[14]

FOOTNOTES

[1]U. S., Department of the Interior, Bureau of Mines, Mineral Industries of Africa (1976), p. 109.

[2]See Executive Office of the President, Council on International Economic Policy, Special Report: Critical Imported Materials (December 1974), pp. 16-17; Raymond F. Mikesell, Nonfuel Minerals: U. S. Investment Policies Abroad, The Washington Papers Vol. 3, No. 23 (Beverly Hills: Sage Publications, 1975), pp. 37-38; and John E. Tilton, The Future of Nonfuel Minerals (Washington, D. C.: The Brookings Institution, 1977), pp. 89-90.

[3]Robert Dickson and Paul Rogers, "Resources, Producer Power and International Relations," in Future Resources and World Development, ed. Paul Rogers (New York: Plenum Press, 1976), pp. 78-79.

[4]See Kenneth W. Clarfield et al., Eight Mineral Cartels: The New Challenge to Industrial Nations (n.p.: METALS WEEK, 1975), pp. 1-2; and U. S. Department of the Interior, Annual Report of the Secretary of the Interior Under the Mining and Minerals Policy Act of 1970 for 1977, pp. 146-147.

[5]Zuhayr Mikdashi, The International Politics of Natural Resources (Ithaca: Cornell University Press, 1976), p. 197.

[6]U. S., Executive Office of the President, Critical Materials, p. 19; Mikdashi, International Politics, pp. 147-149; Mikesell, Nonfuel Minerals, pp. 47-52; Alexander Sutulov, Minerals in World Affairs (Salt Lake City: University of Utah Printing Services, 1972), pp. 162-165; and Tilton, The Future, pp. 40-41.

[7]See Robert McAuley, "The Scramble for Resources," Business Week (30 June 1973): 63; and Mikdashi, International Politics, pp. 157-170.

[8]These points are discussed thoroughly in Mikesell, Nonfuel Minerals, pp. 27-28; and Rogers, Future Resources, pp. 53-54.

[9]See Mikesell, Nonfuel Minerals, pp. 58-62; Sanford Rose, "Third World 'Commodity Power' Is a Costly Illusion," Fortune (November 1976): 149-150, 158; Tilton, The Future, p. 94; and Bension Varon and Kenji Takeuchi, "Developing Countries and Non-Fuel Minerals," Foreign Affairs (April

1974): 505-510.

[10]See U. S., Congress, Congressional Budget Office, U. S. Raw Materials Policy: Problems and Possible Solutions, Background Paper No. 16 (28 December 1976), pp. 26-29; and U. S., Department of the Interior, Bureau of Mines, Draft of Strategic and Tactical Plan (January 1976), pp. II-43-II-45.

[11]Tilton, The Future, pp. 64-67.

[12]See Congress, U. S. Raw Material Policy, pp. 24-26; and Bureau of Mines, Draft of Strategic, pp. II-46-II-50.

[13]See Congress, U. S. Raw Material Policy, pp. 30-33; and Tilton, The Future, pp. 68-71.

[14]Tilton, The Future, pp. 71-72.

CHAPTER III

ANALYSIS OF CASE STUDY MINERALS

Methodology

In order to assess the major concerns addressed in this research, a framework of the factors pertinent to the individual minerals that will contribute to a crisis must be established.

The first factor essential to the analysis is the mineral's use and importance in United States industry. This will establish the extent of involvement and relative importance to the economy of that particular mineral. Second, the areal distribution and production is presented in order to focus on the geography of the mineral. Discussed are the mineral's physical occurrence in terms of reserves and resources, and the countries in which active profitable extraction is taking place. The third factor involves the supply-demand relationships which will show the components of supply, quantities demanded, and the sources so that a pattern of reliance can be established. The fourth factor addresses the possibility of substitution in order to determine how dependent industry is on that particular mineral. It is also essential to know what the substitutes are because the use of one critical material in lieu of another could create

further problems. The fifth factor presents the economic aspects of the mineral in order to determine any future price trends. The sixth factor is the forecast demand for the United States and the rest of the world. The projected demand in the year 2000 and cumulative requirements from the present to 2000 are compared against domestic and world reserves and resources to determine physical shortages. Strategic considerations are then discussed to see what impact the supply problems of a particular mineral would have on the military-industrial complex in time of war. Finally, the potential for cartel-like action to restrict supplies or raise prices is addressed to evaluate the nation's vulnerability to producer power.

Data Sources

The major data source for this analysis is the United States Department of the Interior, Bureau of Mines. This organization is charged with the bulk of resource conservation, information dissemination, and investigative programs in mineral related activities.[1] Various other government and private sources were referred to, but it appears that the agencies within the Department of the Interior are the originating source. However, the other sources are valuable to corroborate analysis.

Chromium

Uses and Importance In United States Industry

Chromium is perhaps one of modern industry's most versatile elements and is one of the United States most important strategic and critical materials. It has a wide range of uses in the metallurgical, chemical, and refractory industries. Its two most important uses are in high strength stainless steels and metal plating. Chromium enhances such properties as hardenability, creep and impact strengths, and resistance to corrosion, oxidation, wear, and galling. Other important uses are in alloy steels, nickel-chromium heating elements, pigments, leather processing, catalysts, and refractories. It is important as a refractory because the major application is in iron and steel processing, nonferrous alloy refining, glass making, and cement processing.[2]

Areal Distribution and Production

Chromite, the ore for chromium, occurs worldwide; however, most of the reserves and identified resources are located in the Eastern Hemisphere (see Table 2). Detailed exploration has not been accomplished in most countries; therefore, data is limited to those estimates on the basis of surface geology and information on reserves.

The world's largest known deposit is located in the Bushveld Complex, Transvaal, Republic of South Africa.

Table 2

Identified World Chromite Ore Reserves

(Thousand short tons)

Country	High chromium		High iron		High aluminum	
	Reserves	Other	Reserves	Other	Reserves	Other
Western Hemisphere						
United States	50	400	----	5,600	----	100
Brazil	2,800	3,400	3,900	2,200	100	150
Canada	----	100	----	2,800	----	----
Cuba	----	100	----	----	280	1,100
Greenland	----	----	----	11,000	----	----
Other	----	200	----	----	----	----
Hemisphere total	2,850	4,200	3,900	21,600	380	1,350
Eastern Hemisphere						
Finland	----	----	11,000	5,600	----	----
Greece	50	50	----	----	50	50
India	5,600	4,500	2,200	2,200	----	----
Iran	1,700	1,100	----	----	----	----
Madagascar, Democratic Republic of	4,500	3,400	1,100	2,200	----	----
Philippines	780	560	----	----	4,500	2,200
Rhodesia, Southern	560,000	560,000	56,000	56,000	----	----
South Africa, Republic of	56,000	56,000	1,100,000	2,200,000	----	----
Turkey	5,600	5,600	----	----	----	----
U S S R	11,000	11,000	1,100	2,200	11,000	11,000
Other	1,100	1,100	1,100	1,100	----	----
Hemisphere total	646,330	643,310	1,172,500	2,269,300	15,550	13,250
World total *(rounded)*	650,000	650,000	1,200,000	2,300,000	16,000	15,000

Source: U. S., Department of the Interior, Bureau of Mines, Chromium-77, by John L. Morning, Mineral Commodity Profiles, MCP-1 (Washington, D. C.: Government Printing Office, 1977), p. 5.

The South African reserves have been estimated in excess of 1.1 billion tons of chromite with an additional identified subeconomic resource of over 2.2 billion tons. When hypothetical and speculative resources are included, South Africa's total chromite resources would exceed 6 billion tons.

The second largest deposit is in the Great Dyke Region of Southern Rhodesia. It contains estimated reserves of 616 million tons of chromite. The Republic of South Africa and Rhodesia account for 95 percent of the world's chromite reserves and 98 percent of the identified resources. Even with these African countries excluded, the chromite resource in the Eastern Hemisphere is approximately three times that of the Western Hemisphere. In addition, little is known of the Soviet Union's resource position. Regardless, conservative estimates place the U.S.S.R. as the third largest potential source of chromite and it is the world's leading producer.

The United States chromite resources occur mainly in Montana, Oregon, California, Washington, and Alaska. Domestic mine production was last reported in 1961. These deposits are not competitive with foreign ore because of their lack of size, low grade and/or long distance from consumers, located mainly in the East. The effect of rising energy costs on mining low grade ores will most

likely widen the economic gap.[3]

Supply-Demand Relationships

In 1976, the United States industrial demand for chromium was 518,000 tons which equaled 18 percent of the world production. The components of supply to meet this demand are imports, secondary production, Government stockpile excess, and industry stocks. Table 3 shows the supply components and demand pattern for 1965 to 1976. Figure 4 shows chromium data for 1961 to February 1978.

The largest supply component for several years has been imports. The United States net import reliance as a percent of apparent consumption for selected years was:[4]

1950	1955	1960	1965	1970	1971
95%	83%	85%	92%	89%	84%

1972	1973	1974	1975	1976	1977
91%	91%	90%	90%	89%	89%

The principal suppliers of chromium to the United States during 1973 to 1976, the U.S.S.R., the Republic of South Africa, Turkey, the Philippines, and Southern Rhodesia, are also the leading producers (see Figure 2). In 1976, the share among these major foreign suppliers was the Republic of South Africa, 36 percent; Turkey, 12

Table 3

Chromium Supply-Demand Relationships, 1965-76

Thousand short tons of chromium

	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976*
World production:												
United States	0	0	0	0	0	0	0	0	0	0	0	W
Rest of world	1,708	1,550	1,635	1,736	1,814	2,050	2,184	2,184	2,328	2,583	2,778	2,830
Total	1,708	1,550	1,635	1,736	1,814	2,050	2,184	2,184	2,328	2,583	2,778	2,830
Components of U.S. supply:												
Domestic mines	---	---	---	---	---	---	---	---	---	---	---	W
Secondary	43	49	43	45	61	58	63	52	53	65	38	57
Net Sales Government stockpile excess	---	22	23	44	79	78	42	55	60	142	110	50
Imports, chromite ore	469	575	389	341	346	443	403	341	282	329	382	350
Imports, alloys	38	66	39	42	44	26	54	92	113	107	202	169
Imports, chemicals	7	9	4	6	4	4	4	5	3	2	1	1
Industry stocks, Jan. 1	405	372	429	406	328	256	269	382	338	239	219	482
Total U.S. supply	962	1,094	927	884	862	865	835	927	869	884	952	1,109
Distribution of U.S. supply:												
Industry stocks, Dec. 31	372	429	406	328	256	269	382	338	239	219	482	521
Exports, alloy and chemicals	9	6	10	20	19	21	7	11	16	9	12	10
Export, chromite ore	24	45	39	33	46	26	42	18	13	31	48	60
Industrial demand	557	614	472	503	541	549	404	560	601	625	410	518
U.S. demand pattern:												
Transportation	86	97	75	80	90	90	80	95	107	103	80	102
Construction	118	132	101	109	118	121	91	125	135	140	95	98
Machinery	81	91	70	74	85	80	60	86	90	90	62	78
Fabricated metal products	28	32	25	26	29	30	25	34	36	40	27	36
Refractories	124	123	93	94	94	90	63	70	77	86	43	68
Plating of metals	13	15	13	15	16	16	14	18	18	17	14	16
Chemicals	51	46	42	47	49	48	39	52	55	61	37	48
Other	56	78	53	58	60	74	32	80	83	88	52	72
Total U.S. primary demand (industrial demand less secondary)	514	565	429	458	480	491	341	508	548	560	372	461

*Preliminary W Withheld

Source: U. S., Department of the Interior, Bureau of Mines, Chromium-77, by John L. Morning, Mineral Commodity Profiles, MCP-1 (Washington, D.C.: Government Printing Office, 1977), p. 8.

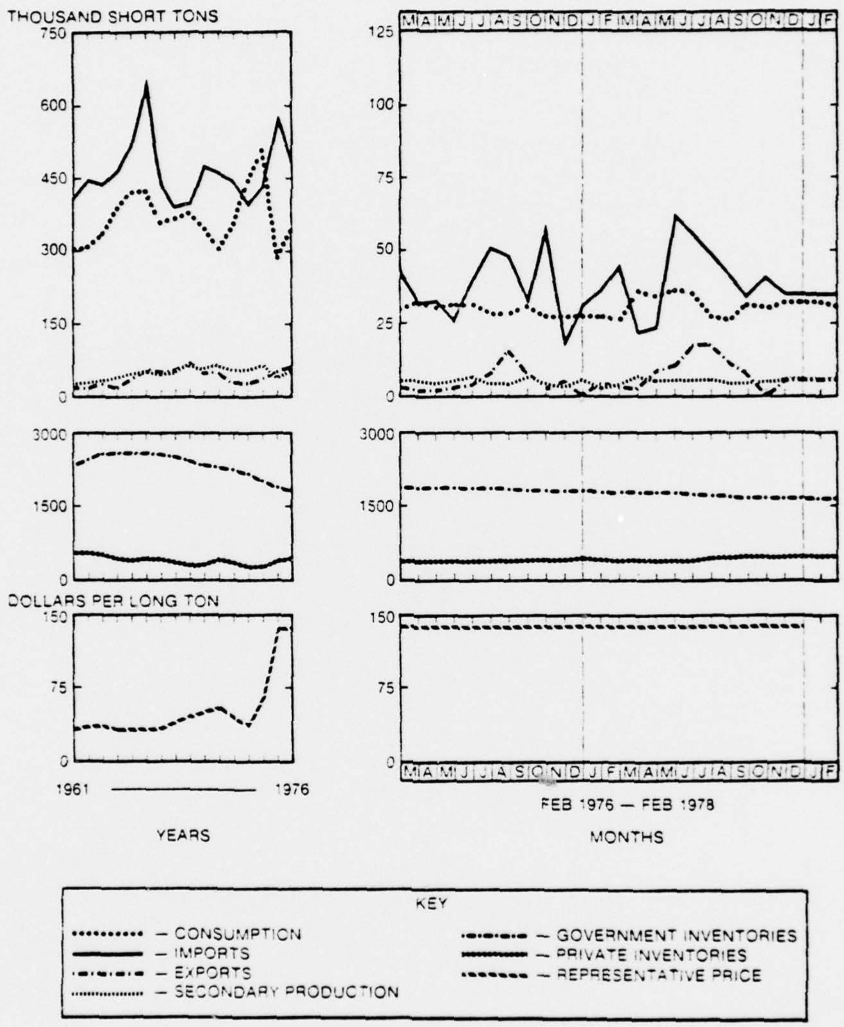


Figure 4

Chromium Data, 1961-78

Source: U. S., Department of the Interior, Bureau of Mines, Minerals and Materials/A Monthly Survey (January 1978), p. 22.

percent; U.S.S.R., 12 percent; Southern Rhodesia, 9 percent; and the Philippines, 7 percent.

Ore has been the principal form of imports in the past; however, beginning in 1972 the trend has been for increasing quantities of alloy imports as the countries with these reserves increase alloy manufacturing capacity (see Figure 3). The major suppliers of alloys in 1975 were Southern Rhodesia and the Republic of South Africa as shown in Figure 5.

Within the United States, consuming industries are forced to hold large stocks of chromium because most of it is imported from the Eastern Hemisphere making supply lines long. These stocks will vary because they are drawn down during strong economic years and are built-up during weak ones. Additionally, changes in Government stockpile criteria have created large stockpile excesses of chromium. Sales of these excesses became a factor in chromium supply beginning in 1966 (see Table 3). However, these excesses were reduced in 1976 when new stockpile goals were established.

Secondary sources such as scrap provide a hidden inventory. There exists large amounts of chromium contained in products throughout the economic system that could be recycled in the event of severe price pressures or shortages. For example, in 1976, stainless steel

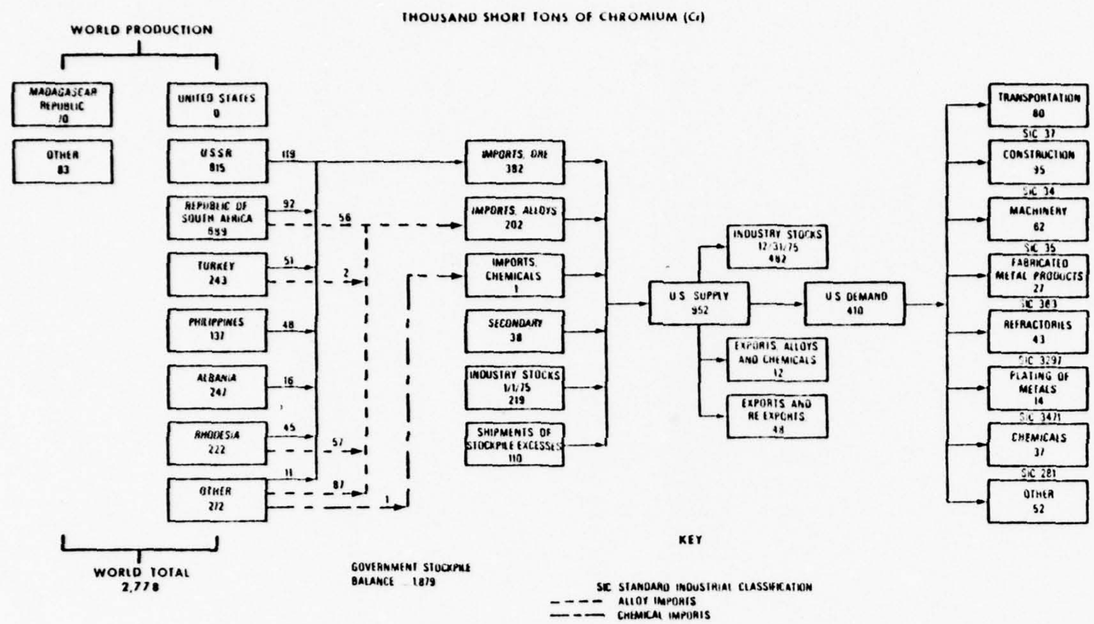


Figure 5

Chromium Supply-Demand Flows, 1975

Source: U. S., Department of the Interior, Bureau of Mines, Chromium-77, by John L. Morning, Mineral Commodity Profiles, MCP-1 (Washington, D. C.: Government Printing Office, 1977) p. 9.

producers shipped approximately 61 percent of their production and returned most of the remainder to the melting cycle as home scrap while purchased scrap accounted for 11 percent of the domestic chromium demand.

Substitutes

There is no known substitute for chromium in high-grade stainless steelmaking.[5] For example, in World War II, boron containing steel was used in lieu of high strength chromium-nickel grade steel. This resulted in lower fatigue properties which caused many failures.[6] In other applications of stainless steel, there is a wide variety of industrial materials that can be substituted such as nickel, cobalt, columbium, vanadium, or molybdenum. However, the use of these materials in lieu of chromium generally is more costly and usually lowers performance standards.

In the two principal chemical uses of chromium, pigments and plating, substitution has a more favorable posture, but cost and sacrifice in desired properties are disadvantages. As with high-grade stainless steel, there is no satisfactory substitute for chromium in industrial hard plating. Nickel, cadmium, and zinc are considered as functional substitutes in some plating applications.

It should be noted that in most cases of substitu-

tion, the alternates are also critical industrial materials.

Economic Factors

The price of chromium is affected by its relative inelasticity of demand, by sales from Government stockpile excesses, and by political activities (see Figure 4).

When most of the Government stockpiles were accumulated during the 1950s, the average price of chromium in terms of 1975 dollars was $300 per ton. However, at the termination of the program, the industry was left with surplus capacity and the average price dropped to a low of $188 per ton in 1967 in terms of 1975 dollars.

Political activity within the United Nations brought about economic sanctions against Southern Rhodesia.[7] This resulted in increased prices for chromium until 1972 when the United States allowed Rhodesian imports.

Worldwide inflationary pressures and a strong demand for chromium increased prices beginning in 1974. These high prices are evident through 1977 and will most likely persist given inflationary pressures and the continued high demand for chromium (see Figure 4).

Future Trends in Demand-Supply

The primary chromium requirements of the United States in 2000 are expected to be 1.1 million tons which equates to an annual growth rate of 3.4 percent for the forecast period 1975 to 2000. The rest of the world's

primary demand is forecast at 4.2 billion tons which corresponds to an annual growth rate of 3.7 percent for the same period. This growth rate is forecast to exceed that of the United States because of increasing industrialization by countries with resources and low-cost energy.

The cumulative requirements in the United States over the forecast period is 19 million tons. With all known domestic chromium bearing materials considered, the domestic resource totals only 2.4 million tons of recoverable chromium. The rest of the world cumulative demand for this period is 70 million tons which brings the total world probable demand to 89 million tons. World chromium reserves, particularly those in Africa, are more than adequate to meet the forecast demand. The ratio of recoverable reserves to cumulative demand is 5.7.[8]

Strategic Considerations

Chromium is critical because it is essential for the manufacturing of high-grade stainless steel required in both civilian and military applications. Domestic chromium supplies have been of concern in every national emergency since World War I. Domestic resources are of such low grade that even under the most critical conditions or Government subsidy programs, domestic production would satisfy only a small fraction of demand. With world

reserves concentrated mainly in the Eastern Hemisphere, possible supply interruptions could be caused from long shipping lines as well as changing political and economic conditions.[9]

Potential for Cartel-Like Action to Restrict Supplies or Raise Prices

The major producers of chromium ore, the U.S.S.R., Turkey, the Republic of South Africa, and Southern Rhodesia, appear to be unlikely partners for joint action. However, supply restrictions by a South Africa-Rhodesian cartel would require only tacit cooperation of the U.S.S.R. to be successful, as is occurring in diamonds. The small number of producers, along with the absence of any substitute for chromium in high-grade stainless steel, make the probability that demand will not drop significantly with any moderate price increase. Thus, a potential problem exists in chromium; however, the current political polarization among the chromite producers makes the possibility for a sustained cartel-like action appear remote.[10]

Cobalt

Uses and Importance In United States Industry

Cobalt is a relatively expensive metal which contributes greatly to sophisticated industrialization. It is an essential element in many alloys and an important ingredient in chemical compounds. Cobalt is one of several

vital alloying elements in aerospace and electrical product industries. As an alloy, cobalt imparts essential qualities such as heat resistance, high strength, wear resistance, and superior magnetic properties.[11] The major end uses in 1976 were magnets, 28 percent; aircraft, 18 percent; machinery, principally cutting tools, 16 percent; paint dryers, 15 percent; ceramics, 12 percent; chemicals, 9 percent; and others, 2 percent.[12]

Areal Distribution and Production

Most of the world's identified resources are located in tropical regions in the form of lateritic nickel ores. Table 4 shows the identified world cobalt resources. Most of these resources are only available as by-products of mining for more abundant elements such as nickel, copper, iron, lead, and zinc. Production as a primary metal requires a relatively high-grade, extensive ore body such as that found in Morocco. However, this deposit is expected to be economically depleted over the next ten years.

The United States has extensive resources of cobalt but none are considered as reserves. The Blackbird district of Lehmi County, Idaho, was one of the rare locations where cobalt had been mined as a primary product, but the mine closed in 1959. Cobalt was mined as a by-product in Idaho, Missouri, and Pennsylvania, but the last of these

Table 4

Identified World Cobalt Resources[1]

(Million pounds)

	Estimated reserves	Other identified resources[2]	Total identified resources[2]
North America:			
United States	0	1,684	1,684
Canada	66	484	550
Cuba	240	2,072	2,312
Total	306	4,240	4,546
Europe:			
Finland	40	10	50
U.S.S.R.	460	40	500
Total	500	50	550
Africa:			
Botswana	58	12	70
Morocco	28	2	30
Zaire	1,000	500	1,500
Zambia	250	516	766
Total	1,336	1,030	2,366
Oceania:			
Australia	108	542	650
New Caledonia	600	250	850
Philippines	420	30	450
Total	1,128	822	1,950
World total[3]	3,300	6,100	9,400

[1] Revised March 1977. [2] Derived in consultation with the U.S. Geological Survey. [3] Rounded to 2 significant figures. Excludes cobalt associated with seabed manganese nodules.

Source: U. S., Department of the Interior, Bureau of Mines, Cobalt-77, by Scott F. Sibley, Mineral Commodity Profiles, MCP-5 (Washington, D. C.: Government Printing Office, 1977), p. 6.

mines closed in 1971. The largest identified cobalt resource in the United States is in Minnesota with approximately 1 billion pounds of cobalt in the form of sulfide.[13]

Cobalt is also found in manganese nodules which lie in deep seabed areas of the earth's oceans. These nodules contain approximately .2 to .4 percent cobalt. The economics and legality of mining seabed nodules and their total resources are still uncertain.[14]

The leading producers in 1976 of cobalt, in terms of mine production, were Zaire, 50 percent; Zambia, 9 percent; Australia, 8 percent; Morocco, 6 percent; New Caledonia, 6 percent; and Canada, 5 percent. In terms of refined metal cobalt production, the leading producers in 1975 were Zaire, 65 percent; Zambia, 9 percent; U.S.S.R., 8 percent; and France, 4 percent.[15]

Supply-Demand Relationships

The United States is one of the principal consumers of cobalt. In 1975, the total use of cobalt equated to 31 percent of the world production. The components of supply are imports, secondary materials, Government stockpile, and industry stocks. Table 5 shows these components and the demand patterns for 1966 to 1976. Figure 6 presents cobalt data for 1961 to 1978.

Imports have been the main component of supply for United States industry for several decades. The net

Table 5

Cobalt Supply-Demand Relationships, 1966-76

(Thousand pounds)

	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976
World production											
United States	1,215	1,168	1,176	1,003	697	690					
Rest of world	46,782	44,028	41,968	43,556	52,590	54,598	54,752	64,856	71,582	72,564	NA
Total	47,997	45,196	43,144	44,559	53,287	55,288	54,752	64,856	71,582	72,564	NA
Components of U.S. supply											
Domestic mines	1,215	1,168	1,176	1,003	697	690					
Secondary	48	120	143	328	69	125	197	264	270	342	329
Shipments of Government stockpile excesses	762	6,189	4,953	6,007	5,162	1,683	5,945	8,569	8,936	6,346	6,698
Imports	18,823	8,215	9,068	12,911	12,417	10,912	13,915	19,238	16,122	6,608	16,487
Industry stocks, Jan. 1	3,600	6,400	6,552	5,888	5,128	5,733	5,235	4,534	9,184	9,467	6,902
Total U.S. supply	24,448	22,092	21,892	26,137	23,473	19,143	25,292	32,605	34,512	22,763	30,416
Distribution of U.S. supply:											
Industry stocks, Dec. 31	6,400	6,552	5,888	5,128	5,733	5,235	4,534	9,184	9,467	6,939	8,864
Exports	100	200	1,420	1,497	1,478	365	1,293	1,398	1,348	1,768	1,751
Industrial demand	17,948	15,340	14,584	19,512	16,262	13,543	19,465	22,023	23,697	14,056	19,801
U.S. demand pattern											
Nonmetal											
Paints	1,451	1,044	1,451	1,285	2,152	2,042	2,323	2,646	2,807	1,965	2,943
Chemicals	753	696	882	1,382	538	707	1,270	1,635	1,959	1,523	1,783
Ceramics and glass	1,580	1,135	1,281	858	1,890	1,768	1,982	2,228	2,331	1,630	2,348
Total nonmetal	3,784	2,875	3,614	3,525	4,580	4,517	5,575	6,509	7,097	5,118	7,074
Metal											
Transportation: Aircraft	4,482	3,575	2,544	4,046	3,297	2,518	4,294	4,023	5,290	2,636	3,458
Electrical	5,387	4,160	5,100	4,024	4,589	3,633	6,069	6,460	5,628	3,166	5,513
Machinery											
Machine tools	2,152	1,628	1,616	1,911	1,882	1,376	1,717	2,449	2,853	1,356	1,537
Construction machinery	1,685	1,623	998	1,268	1,179	1,080	1,190	2,034	2,211	1,355	1,608
Total	3,837	3,251	2,614	3,179	3,061	2,456	2,907	4,483	5,064	2,711	3,145
Coating and plating				3,351							
Other	458	1,479	712	1,387	735	419	620	637	618	425	611
Total metal	14,164	12,465	10,970	15,987	11,682	9,026	13,890	15,603	16,600	8,938	12,727
Total U.S. primary demand (total demand less secondary supply)	17,900	15,220	14,441	19,184	16,193	13,418	19,268	21,848	23,427	13,714	19,472
Total U.S. demand for primary metal	14,116	12,345	10,827	15,659	11,613	8,901	13,693	15,339	16,330	8,596	12,398

NA Not available

Source: U. S., Department of the Interior, Bureau of Mines, Cobalt-77, by Scott F. Sibley, Mineral Commodity Profiles, MCP-5 (Washington, D. C.: Government Printing Office, 1977), p. 11.

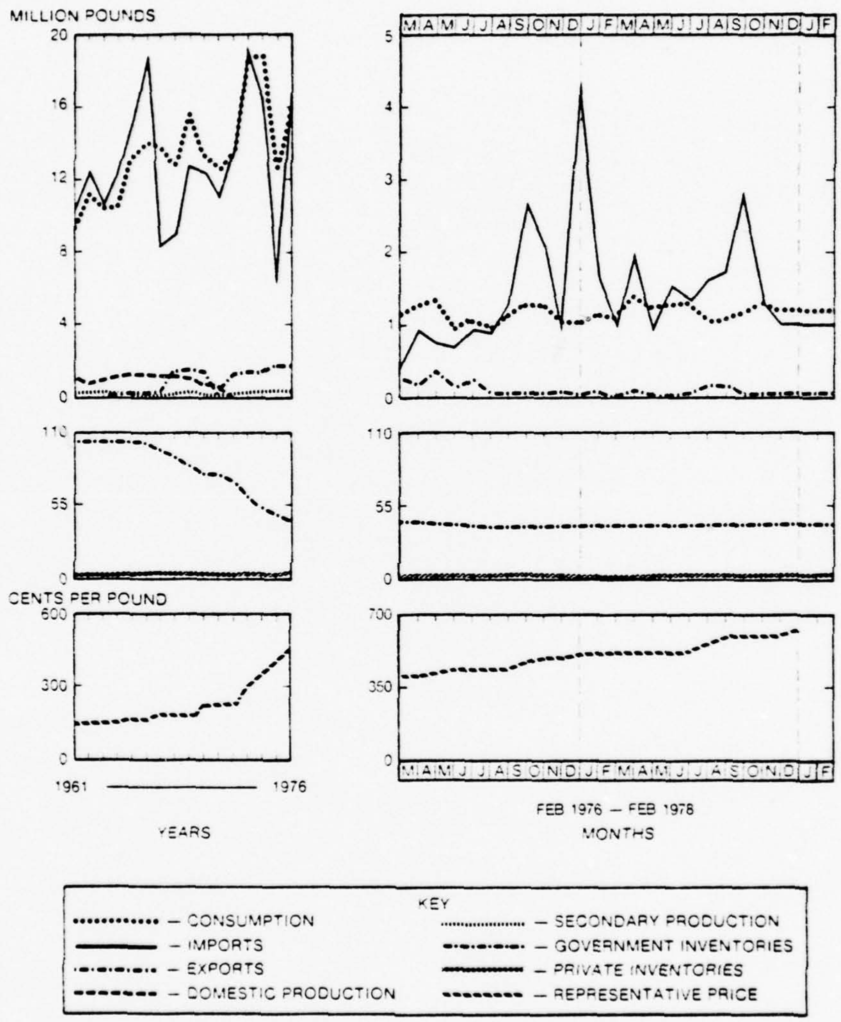


Figure 6

Cobalt Data, 1961-78

Source: U. S., Department of the Interior, Bureau of Mines, Minerals and Materials/A Monthly Survey (January 1978), p. 24.

import reliance of cobalt for selected years is:[16]

1950	1958	1960	1965	1970	1971
90%	68%	66%	92%	98%	96%
1972	1973	1974	1975	1976	1977
98%	98%	99%	98%	98%	97%

The main import sources of cobalt to the United States during 1972 to 1975 were Zaire, 47 percent; Belgium, 28 percent; Finland, 8 percent; Norway, 7 percent; and others, 10 percent. The flow of supply and demand for 1975 is shown in Figure 7. It should be noted that all the cobalt produced by Belgium came from Zaire making it by far the largest supplier of cobalt to the United States.

The 1975 imports of 6.6 million pounds is the lowest figure in the past two decades. The main reason for this low was lagging domestic demand along with generally slower industrial activity. In 1976, imports totaled 16.5 million pounds which is 2.5 times that of 1975. The principal sources in 1976 were Zaire, 41 percent; Belgium, 15 percent; Zambia, 11 percent; Norway, 7 percent; and Botswana, 6 percent.

Cobalt sales of Government stockpile excesses have composed a large portion of the market supply over the past ten years. Releases in 1976 constituted 29 percent of the market supply and 40 percent in 1974 (see

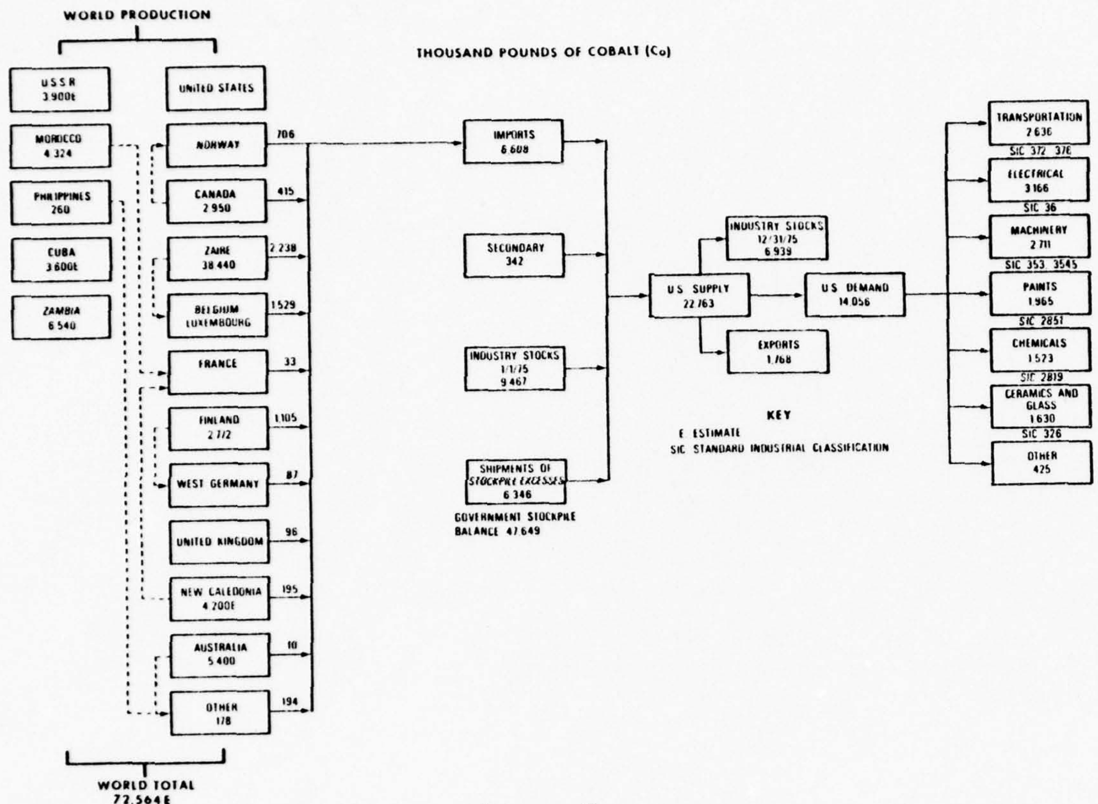


Figure 7

Cobalt Supply-Demand Flows, 1975

Source: U. S., Department of the Interior, Bureau of Mines, Cobalt-77, by Scott F. Sibley, Mineral Commodity Profiles, MCP-5 (Washington, D.C.: Government Printing Office, 1977), p. 10.

Table 5). Several changes in the stockpile goals over the past few years have dramatically affected these excesses. For example, in 1973, the goal was lowered from 38.2 million pounds to 11.95 million pounds. Finally, on October 1, 1976, the goal was raised to 85.4 million pounds. Approximately 5.1 million pounds were sold from the stockpile prior to the October, 1976 change, leaving a balance of 40,725 million pounds. Any further change in this balance will require congressional approval. Currently, without this source of supply, foreign production will have to be increased to meet demand. However, because cobalt is produced as a by-product, production cannot be accelerated without the increased production of nickel and copper. At present, no supply problems have been encountered.

Substitutes

The outlook on substitutes for cobalt is favorable. Usually, nickel is a satisfactory alternate for cobalt as is cobalt for nickel. For example, cobalt was effectively used in electroplating during the 1969 Canadian nickel mining strike. However, when substitutes are used there are some economic disadvantages along with the sacrifice of important properties. Materials such as manganese and lead used as catalysts or as dryers in paint are usually not effective. The substitution of cobalt in

permanent magnets results in the loss of weight advantage and other important physical properties, but this demand is more sensitive to price, thus rendering replacement more likely.

There is no satisfactory substitute for cobalt in carbides, but research in particle metallurgy is promising. It is also difficult to replace cobalt superalloys in gas-turbine engines. Ceramic materials may be a substitute but, because of the relatively low shock resistance of ceramics, many years of development may be required before its use in aircraft.

Economic Factors

Cobalt prices have risen steadily from an annual average of $1.50 per pound in 1964 to $6.40 per pound in February 1978 (see Figure 6). For the period 1973 to 1977, the average annual price increase has been 21 percent with an overall increase of 145 percent. In terms of constant 1975 dollars, the increase was 14 percent per year and 95 percent overall.

Perhaps the most important factors in the cobalt market are cobalt's by-product relationship with either copper or nickel and the consequent price inelasticity of supply. The price range at which supply would be sensitive to price changes is unknown; however, it is thought to be extremely high.

These price increases of cobalt are partly due to the rising costs of mining and refining in foreign countries. Energy is one large expense that influences end product prices with rising costs at each step in production. Factors aside from inflation that have affected the price of cobalt since 1964 are the removal of cobalt from lists of commodities prohibited from being shipped to Sino-Soviet countries, a 30 percent increase in United States industrial consumption resulting from the Vietnam War, nationalization of mines in Zaire in 1967, increased demand caused by the Canadian nickel mining strike, and the currency realignment between Belgium and the United States during 1972 to 1977. Prices will probably continue to rise as demand exceeds supply. The only moderating forces for the long run will be the opening of new sources such as seabed nodule mining or the expansion of mining in New Caledonia, Indonesia, and the Philippines. These offer a potentially large supply, but a great initial capital investment is required.

Future Trends in Demand-Supply

The United States forecast probable demand for cobalt in the year 2000 is 40.4 million pounds, an annual growth rate of 2.9 percent for the forecast period 1976 to 2000. The rest of the world is expected to require 125 million pounds which comes from an annual growth rate

of 3.3 percent. The growth rate of the rest of the world is expected to exceed that of the United States because of the accelerating expansion of sophisticated Japanese industries, the rising use of superalloys in Western Europe, and the use of cobalt alloys for industrial development in countries with centrally planned economies.

Domestic cumulative requirements for primary cobalt from 1976 to 2000 are estimated at 697 million pounds with the rest of the world forecast at 2.03 billion pounds. This brings the total world probable cumulative demand for the forecast period to 2.73 billion pounds. Current estimates of reserves at 3.27 billion pounds are more than adequate to meet world requirements; however, because of the by-product nature, supplies will be available only at the rate of 70 to 90 million pounds per year. The world primary demand for cobalt in 1976 was 74.5 million pounds; therefore, supplies will be adequate based on projected growth rates only until 1981. After this period new major copper and nickel projects must be undertaken. Given high enough prices, domestic production could result in one or several of the higher grade deposits, but this is not expected soon. An additional problem is that the supply of cobalt is relatively inelastic so any decreased production of copper and/or nickel would result in a decline in the supply of cobalt.

Strategic Considerations

Cobalt is considered critical because of its essential uses in the production of high-temperature-resistant alloys for jet engines; as binders in cemented carbides for metal cutting; in mining tools such as drill bits, valves, pipes, and hard facings; as drawing and forming dies and rolls for the manufacture of steel; and as a desulfurizing catalyst in crude oil refining and processing. Additionally, if a high production of jet engines were required, the United States would have difficulty in meeting the demand without using the domestic stockpile.[17]

Potential for Cartel-Like Action to Restrict Supplies or Raise Prices

Zaire, with almost 60 percent of the world's cobalt production, clearly is in the position to increase prices by manipulating supply. However, such action is unlikely since cobalt is a by-product of other valuable mineral production and nickel can be substituted for it in a number of important uses. Additionally, the currently large Government stockpile is a standing deterrent to cobalt producers.[18]

Manganese

Uses and Importance in United States Industry

Manganese is principally used in the form of ferromanganese for the production of iron and steel. Its

traditional but essential role as a desulfurizer and deoxidizer is being surpassed by the alloying effects with steel of strength, toughness, hardness, and hardenability. Manganese also imparts to aluminum such properties as strength, hardness, and stiffness; plus adding hardness, stiffness, and corrosion resistance to magnesium. A small content of manganese allows the melting of magnesium in steel pots by prohibiting their alloying. Manganese bronzes are used extensively for the manufacture of ship propellers and dry cell batteries use manganese dioxide as a depolarizer in the cell.

Areal Distribution and Production

The identified world reserves of manganese ore are approximately two billion tons of contained manganese as shown in Table 6. The data is based on those materials deemed to have reasonable economic prospects of availability within the next 25 years.

The largest supply is in the Republic of South Africa with reserves of .9 million tons and an additional resource of 780,000 tons of contained manganese. The U.S.S.R. has the second largest supply with 750,000 tons in reserves plus 600,000 tons in resources of contained manganese. Together these two countries control 80 percent of the reserves and 84 percent of the identified world resources. The remaining reserves of relative

Table 6

Identified World Manganese Resources[1]

(Thousand short tons of manganese content)

	Reserves	Other	Total
North America:			
United States:			
Arizona	----	6,800	6,800
Arkansas	----	7,800	7,800
Colorado	----	3,800	3,800
Maine	----	33,400	33,400
Minnesota	----	21,800	21,800
Total United States	----	73,600	73,600
Canada	----	17,500	17,500
Mexico	2,200	12,600	14,800
Total North America	2,200	103,700	105,900
South America:			
Bolivia	----	5,000	5,000
Brazil	43,700	26,000	69,700
Chile	450	----	450
Total South America	44,150	31,000	75,150
Europe:			
Bulgaria	4,500	----	4,500
Greece	230	----	230
Hungary	270	----	270
Romania	330	----	330
U.S.S.R.	750,000	600,000	1,350,000
Total Europe	755,330	600,000	1,355,330
Africa:			
Gabon	100,000	----	100,000
Ghana	350	10,000	10,350
Ivory Coast	----	1,500	1,500
Morocco	750	----	750
South Africa, Rep. of	900,000	780,000	1,680,000
Upper Volta	----	10,000	10,000
Zaire	3,400	1,100	4,500
Total Africa	1,004,500	802,600	1,807,100
Asia:			
China, Peoples Rep. of	17,000	17,000	34,000
India	28,000	12,000	40,000
Japan	950	----	950
Thailand	1,300	2,800	4,100
Total Asia	47,250	31,800	79,050
Oceania:			
Australia	160,000	15,000	175,000
Fiji	80	300	380
New Hebrides	80	----	80
Total Oceania	160,160	15,300	175,460
World total (rounded)	2,000,000	1,600,000	3,600,000

[1] Excludes sea-floor deposits.

Source: U. S., Department of the Interior, Bureau of Mines, Manganese-77, by Gilbert L. DeHuff and Thomas S. Jones, Mineral Commodity Profiles, MCP-7 (Washington, D. C.: Government Printing Office, 1977), p. 8.

significance are Australia, 8 percent; Gabon, 5 percent; and Brazil, 2 percent.[19]

Another possible large resource is deep seabed nodules that are reported to contain a manganese content of 27 to 30 percent. However, there are still many unanswered legal and economic questions as to their recovery and production.[20]

There are no domestic reserves of manganese ore at current prices. Identified domestic resources totaling 73.6 million tons of contained manganese are located in Arizona, Arkansas, Colorado, Maine, and Minnesota. These deposits are of such low grade that they are not considered for development except under a dire emergency.[21]

World manganese production totaled 10.8 million tons in 1975. The leading producers were the U.S.S.R., 31 percent; Republic of South Africa, 24 percent; Gabon, 11 percent; Brazil, 8 percent; Australia, 8 percent; India, 6 percent; and the Peoples Republic of China, 4 percent.

The United States has no manganese ore processing industry, but there are several manganese ferroalloy plants. The reported domestic production of manganese comes from manganiferous ore which has more than 5 percent but less than 35 percent manganese content. This ore is generally associated with the iron ore industry, but it contains an important amount of manganese. In

domestic production totaled 29,000 tons of manganese content.[22] However, domestic production is on a downward trend (see Table 7).

Supply-Demand Relationships

The United States demand for manganese in 1976 was approximately 1.3 million tons and accounted for 12 percent of the total world primary production. The components of supply are domestic production, Government stockpile excesses, imports, and industry stocks as shown in Table 7 for the period 1965 to 1976. Manganese data for the period 1961 to 1978 is shown in Figure 8.

Imports have supplied the major portion of demand for several decades with domestic production providing very little. The net import reliance as a percent of apparent consumption for selected years is:[23]

1950	1955	1960	1965	1970	1971
77%	79%	89%	94%	95%	97%
1972	1973	1974	1975	1976	1977
98%	98%	98%	98%	98%	98%

The major import sources for manganese during 1972 to 1975 were the U.S.S.R., 31 percent; United Kingdom, 26 percent; Republic of South Africa, 25 percent; and others, 18 percent.[24]

A trend beginning in 1972 has been for a signifi-

Table 7

Manganese Supply-Demand Relationships, 1965-76

(Thousands short tons of manganese content)

	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976[p]
World production:												
United States	83	88	73	48	93	66	38	29	31	35	19	29
Rest of world	8,717	8,893	8,205	8,549	9,192	8,978	9,960	9,983	10,707	10,185	10,791	10,861
Total	8,800	8,981	8,278	8,597	9,285	9,044	9,998	10,012	10,738	10,220	10,810	10,890
Components of U.S. supply:												
Domestic mines	83	88	73	48	93	66	38	29	31	35	19	29
Shipment of Government stockpile excesses	-101	-53	52	73	50	140	118	218	242	807	309	294
Imports, ore	1,221	1,223	978	870	992	847	938	793	722	593	766	649
Imports, alloy and metal	211	221	193	183	257	238	212	305	336	376	348	478
Industry stocks, Jan. 1	948	977	1,093	1,171	1,180	1,241	1,175	1,281	1,241	978	1,183	1,359
Total U.S. supply	2,362	2,456	2,389	2,345	2,572	2,532	2,481	2,626	2,572	2,789	2,623	2,809
Distribution of U.S. supply:												
Industry stocks, Dec. 31	977	1,093	1,171	1,180	1,241	1,175	1,281	1,241	978	1,183	1,359	1,429
Exports, ore	7	8	8	10	10	10	25	12	29	107	125	64
Exports, alloy and metal	5	2	3	5	4	20	5	7	11	7	6	9
Demand	1,373	1,353	1,207	1,150	1,317	1,327	1,170	1,366	1,554	1,492	1,133	1,307
U.S. demand pattern:												
Construction	268	282	254	276	268	260	252	236	325	317	249	258
Transportation	273	276	243	273	253	226	261	239	340	315	260	265
Machinery	186	196	175	198	185	176	175	171	229	245	185	191
Cans and containers	67	62	59	72	62	73	71	58	72	79	59	61
Appliances & equipment	46	51	49	53	51	51	51	51	68	68	47	53
Oil & gas industries	40	51	39	52	43	42	46	44	63	69	64	56
Chemicals	50	62	59	59	37	37	35	50	54	65	52	47
Batteries	12	18	15	15	20	20	19	18	18	18	16	18
Other[1]	431	355	314	152	398	442	260	499	385	316	201	358
Total U.S. primary demand	1,373	1,353	1,207	1,150	1,317	1,327	1,170	1,366	1,554	1,492	1,133	1,307

[p] Preliminary.
[1] Includes processing losses.

Source: U. S., Department of the Interior, Bureau of Mines, Manganese-77, by Gilbert L. DeHuff and Thomas S. Jones, Mineral Commodity Profiles, MCP-7 (Washington, D. C.: Government Printing Office, 1977), p. 13.

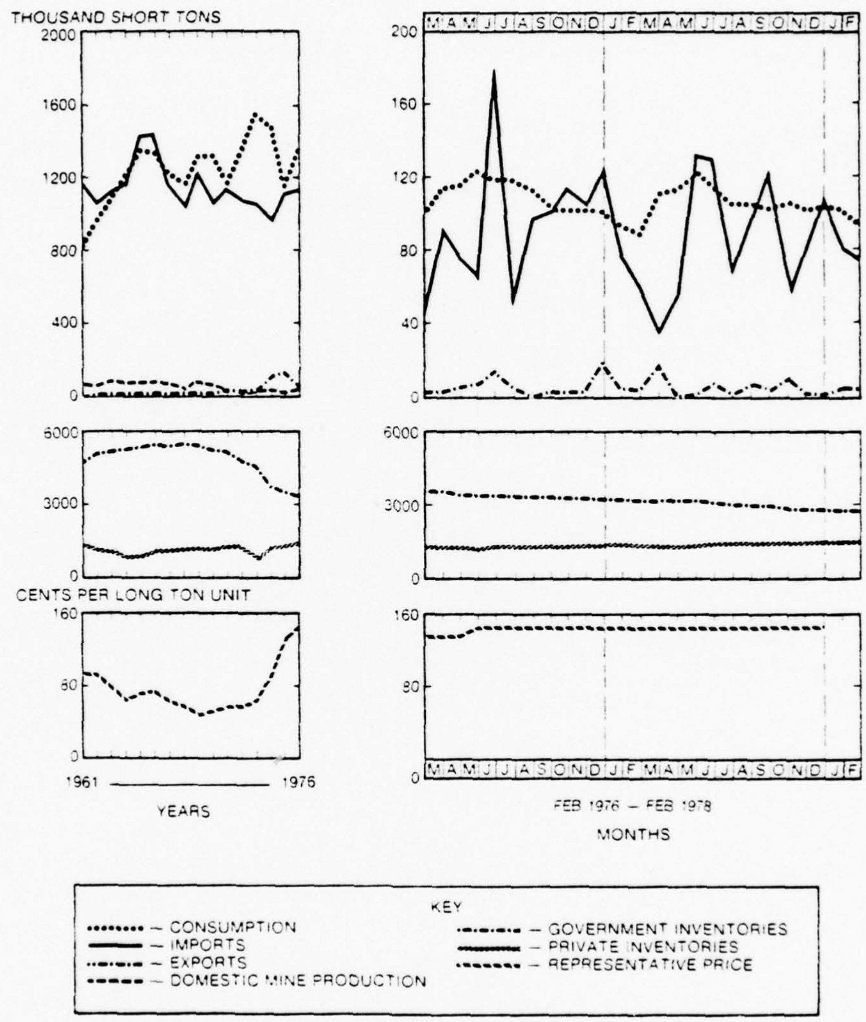


Figure 8

Manganese Data, 1961-78

Source: U. S., Department of the Interior, Bureau of Mines, Minerals and Materials/A Monthly Survey (January 1978), p. 20.

cant increase in imports of metals and alloys with a similar decline in ore imports (see Table 7).

Traditionally, the manganese ferroalloy processing plants have been located in Japan, Norway, and the industrial countries of Europe; however, certain ore producing countries such as the Republic of South Africa have become alloy producers.[25] The principal sources of manganese alloy and metal in 1975 were France, 31 percent; and the Republic of South Africa, 30 percent. The flow of supply-demand is shown in Figure 9.

Substitutes

Manganese is essential for the production of virtually all steels and there is no known satisfactory substitute for this purpose. It is possible that technological developments in steelmaking may require less manganese per ton of steel. There are also equally good possibilities that technology will bring new uses for manganese, such as an antiknock additive for gasoline to replace lead, that will offset any decreased demand from steelmaking.[26]

Economic Factors

Manganese prices are negotiated and are dependent on such variable factors as chemical content, physical character, quantity involved, delivery terms, freight rates, insurance, inclusion or exclusion of export and/or

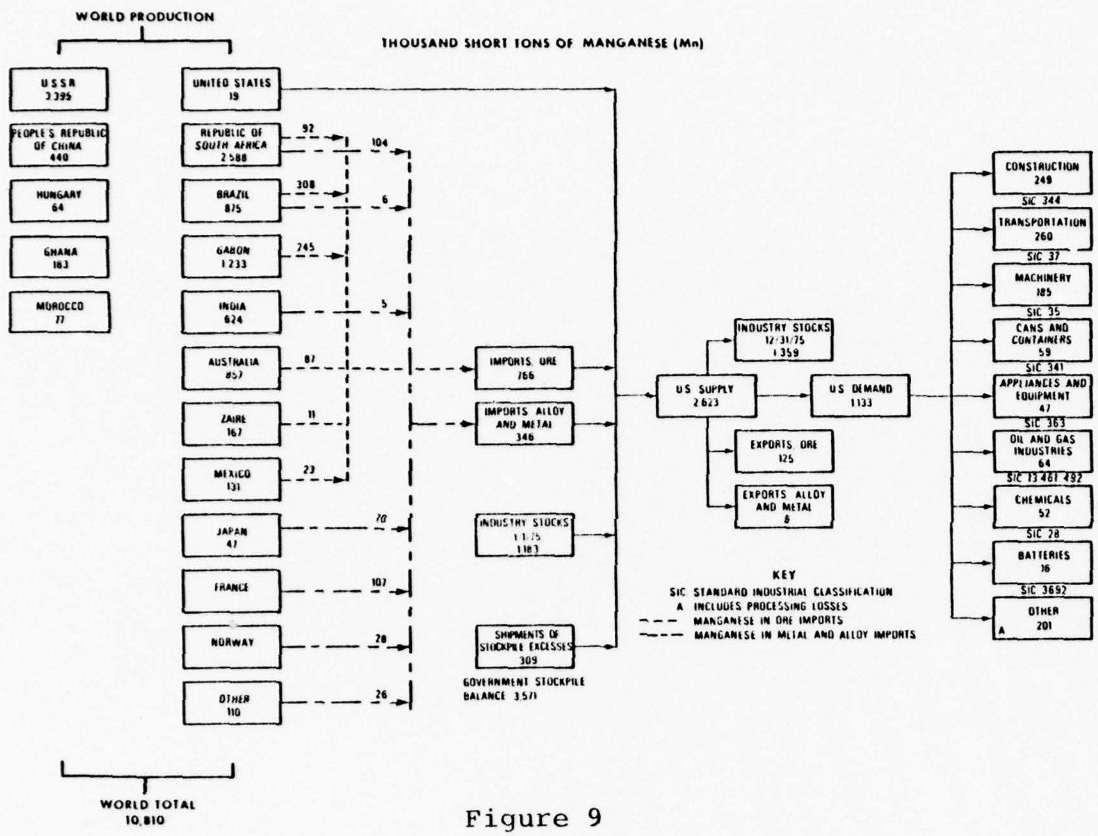


Figure 9

Manganese Supply-Demand Flows, 1975

Source: U. S., Department of the Interior, Bureau of Mines, Manganese-77, by Gilbert L. DeHuff and Thomas S. Jones, Mineral Commodity Profiles, MCP-7 (Washington, D. C.: Government Printing Office, 1977) p. 12.

import duties, needs of the buyer, and general availability of ores of the desired quantity. The single most significant factor has been ocean freight rates, which represent approximately one-third of the price of imported ores to the east coast. Therefore, any appreciable price change could be independent of supply-demand factors. Since large tonnages are involved, long sea routes are further complicated by shortages of vessels and port congestion. Additionally, ore from some of the large deposits must travel great distances before the railhead or shipping port is reached. Regardless, manganese prices experienced a decline from 1957 through 1973, which was due mainly to the development of large, new high-grade deposits in various parts of the world. Prices then began increasing in 1974 as a result of high demands; increased freight, environmental, and energy costs, and inflation. This trend has continued through the close of 1977 and will probably persist with the rising costs of energy and inflation (see Figure 8).

Future Trends in Demand-Supply

The United States probable demand in 2000 is forecast at 2.13 million tons of manganese content, which is an annual average growth rate of 1.7 percent for 1975 to 2000. The growth rate for the rest of the world is expected to be 3 percent annually, which will bring that

demand to 20 million tons in 2000. The higher demand by the rest of the world is based on increased steel production trends.

Cumulative domestic demand for the forecast period is projected at 44 million tons of manganese content. The nation's resources are not adequate to meet such a demand, nor are they expected to contribute to the supply. A straight line projection based on historical records suggests that domestic manganese production in 2000 will be zero. The rest of the world cumulative demand for the forecast period is 354 million tons. This brings the total world cumulative demand to 398 million tons that can be adequately met by the estimated world supply. The ratio of recoverable reserves to cumulative demand has been judged to be 4.9 .

Strategic Considerations

Manganese is considered critical because it is essential for the production of steel. In the time of war, the use of manganese would increase directly with the requirements of steel. Since there is no domestic manganese ore mining industry, the United States is totally dependent on foreign supplies. With such a volume of material involved, it is most improbable that manganese requirements could be shipped by air. Since the bulk of the United States requirements for ore are met by Brazil,

Gabon, and the Republic of South Africa and for metal by France, the Republic of South Africa, and Japan, supplies would be subject to the hazards of ocean shipping in wartime.[27]

Potential for Cartel-Like Action to Restrict Supplies and Raise Prices

An effective manganese cartel would require the cooperation of at least Gabon, Brazil, Republic of South Africa, and Australia. This action would have to take the form of a price leadership group of Brazil, Gabon, India, and Australia with the Republic of South Africa and the U.S.S.R. following. However, for political reasons the Republic of South Africa might be unwilling to join a less developed country producer group. Additionally, Australia would have to consider the adverse affect of such action on her iron ore exports to Japan, which is Australia's most important market. Iron ore is in plentiful supply so Japan could shift to a more stable supplier. The same situation is true for India, which exports both manganese and iron ore to Japan. Brazil is a substantial iron ore supplier to Western Europe. Any supply restriction on manganese may affect the available market for iron ore. Finally, price increases or supply restrictions could add impetus to seabed recovery of manganese nodules. Therefore, it is unlikely that concerted action for a manganese cartel would occur.[28]

Nickel

Uses and Importance in United States Industry

Nickel is primarily used in alloys with other elements where it adds strength and corrosion resistance over a wide range of temperatures. It is found extensively in one form or another throughout industry.[29] For example, in 1976, nickel was consumed in the production of stainless and alloy steels, 44 percent; non-ferrous alloys, 35 percent; and electroplating, 16 percent.[30]

The use of nickel is considered vital to the $42 billion iron and steel industry and has had a key role in the development of the current $30 billion aerospace industry. The principal end users are manufacturers of chemicals and allied products and petroleum refiners in the form of metal alloys applied where manufacturing equipment parts are exposed to corrosive chemicals.[31]

Areal Distribution and Production

World nickel reserves have been estimated at 60 million tons; however, these estimates are based on fragmentary information and are probably low. The identified world resources total 175 million tons of nickel as shown in Table 8. The largest deposits are found in New Caledonia with 15 million tons of reserves and an additional 31.3 million tons of resources, which accounts for 26 percent of the world's identified nickel resources. Canadian

Table 8

Identified World Nickel Resources[1]

(Thousand tons)

	Reserves	Other resources[2]	Total resources[2]
North America:			
United States	200	14.900	15.100
Canada	9.600	11.600	21.200
Total	9.800	26.500	36.300
Africa:	2.300	6.700	9.000
Central America and Caribbean Islands:			
Cuba	3.400	14.200	17.600
Dominican Republic	1.100	100	1.200
Guatemala	300	900	1.200
Puerto Rico	----	900	900
Total	4.800	16.100	20.900
Europe: U.S.S.R.	8.100	13.200	21.300
Oceania:			
Australia	5.600	3.200	8.800
Indonesia	7.800	6.600	14.400
New Caledonia	15.000	31.300	46.300
Philippines	5.400	5.800	11.200
Total	33.800	46.900	80.700
South America:			
Brazil	200	3.300	3.500
Colombia	900	600	1.500
Venezuela	----	700	700
Total	1.100	4.600	5.700
World Total (rounded)[3]	60.000	114.000	175.000

[1] Revised March 1977.
[2] Derived in consultation with U.S. Geological Survey.
[3] Excludes nickel associated with seabed manganese nodules.

Source: U. S., Department of the Interior, Bureau of Mines, Nickel-77, by John D. Corrick, Mineral Commodity Profiles, MCP-4 (Washington, D. C.: Government Printing Office, 1977), p. 6.

deposits are the second largest with 9.6 million tons in reserves and 11.6 million tons in additional resources. The other significant world resources are located in Cuba, 10 percent; Indonesia, 8 percent; and the Phillipines, 6 percent.

The United States nickel resources located in Oregon, California, Washington, and Minnesota total 15.1 million tons, but only 200,000 tons are considered as reserves. The reserves are located at the operating mine near Riddle, Oregon. Some of the other deposits are as high grade as the reserves at Riddle, but cannot be profitably mined under current economic conditions.[32]

World nickel mine production totaled 898 thousand tons in 1975. In market-economy countries, the nickel industry is located principally in Canada, New Caldonia, and Australia, which shared this world production with 30 percent, 16 percent, and 9 percent, respectively. The U.S.S.R. is among the leading world producers with a share of 18 percent. Domestic production at 14.3 thousand tons contributed less than 2 percent to the world total.[33]

Supply-Demand Relationships

The United States industrial demand for nickel in 1976 was 213.2 thousand tons which was approximately 24 percent of the total world nickel mine production that year.

Domestic supply requirements of 352.4 thousand tons were satisfied from domestic mine production, 4 percent; secondary production, 13 percent; Government stockpile excesses, .1 percent; imports, 54 percent; and industry stocks, 29 percent. Table 9 shows the supply components and demand patterns for 1966 to 1976. A graphic presentation of the data on nickel from 1961 to 1978 is shown in Figure 10.

Imports are the largest component of United States supply and have been for several decades. The net import reliance as a percent of apparent consumption for selected years is:[34]

1950	1955	1960	1965	1970	1971
90%	84%	72%	73%	71%	60%
1972	1973	1974	1975	1976	1977
65%	69%	72%	72%	72%	70%

The major foreign sources of nickel for the period 1972 to 1975 were Canada, 64 percent; Norway, 8 percent; New Caledonia, 7 percent; Dominican Republic, 6 percent; and others, 15 percent.[35] Canada is by far the largest single foreign source of nickel for the United States. In addition to direct shipments, significant amounts make their way from Canada through processing plants in Norway and the United Kingdom. These accounted

Table 9

Nickel Supply-Demand Relationships, 1966-76

(Thousand tons)

	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976[p]
World mine production:											
United States[1]	13.2	14.6	15.2	15.8	15.6	15.6	15.7	13.9	14.1	14.3	13.9
Rest of World	426.9	480.2	532.9	516.9	676.8	685.0	666.2	707.7	809.1	883.3	906.1
Total	440.1	494.8	548.1	532.7	692.4	700.6	681.9	721.6	823.2	897.6	920.0
Components of U.S. supply:											
Domestic mines	13.2	14.6	15.2	15.8	15.6	15.6	15.7	13.9	14.1	14.3	13.9
Secondary	63.1	52.3	36.6	71.0	48.7	63.1	67.5	65.9	64.5	41.6	47.0
Shipments of Government stockpile excesses	103.6	22.3	3.2	4.3	2.1	14.9	1.8	1.0	4.6	4	0.5
Imports	141.0	143.0	148.0	129.3	156.3	142.2	173.9	191.1	220.7	162.3	188.6
Industry stock, Jan. 1	14.1	44.5	39.6	37.2	31.9	24.7	57.3	77.9	71.3	87.3	102.4
Total U.S. supply	335.0	277.7	242.6	257.6	254.6	260.5	316.2	349.8	375.2	305.9	352.4
Distribution of U.S. supply:											
Industry stock, Dec. 31	31.3	34.6	37.3	31.9	24.7	57.3	77.9	71.3	87.3	102.4	123.4
Exports	11.8	8.0	6.5	2.3	6.5	4.6	3.0	5.0	4.3	7.4	15.8
Industrial demand	291.9	235.1	198.8	223.4	223.4	198.6	235.3	273.5	283.6	196.1	213.2
U.S. demand pattern:											
Chemicals	21.4	26.0	22.4	34.3	33.4	29.7	35.2	41.2	43.0	28.0	31.1
Petroleum	11.7	14.1	12.4	17.3	17.8	17.9	21.3	24.7	26.1	18.5	18.6
Fabricated metal products	28.7	40.3	25.0	18.7	21.3	20.3	23.6	27.5	26.1	17.3	18.7
Transportation:											
Aircraft	30.4	16.5	24.3	14.9	13.4	13.9	16.2	19.2	17.0	11.9	18.1
Motor vehicles and equipment	36.4	24.0	22.1	23.4	26.7	21.8	26.4	30.2	29.4	21.5	22.7
Ship and boat building and repairs	11.7	7.3	9.2	8.6	6.6	6.1	6.8	8.4	13.4	10.2	8.7
Total	78.5	47.8	55.6	46.9	46.7	41.8	49.4	57.8	59.8	43.6	49.5
Electrical	34.7	20.2	20.7	30.0	28.8	25.7	30.6	35.6	34.4	25.6	26.9
Household appliances	28.9	18.4	18.7	13.7	14.5	13.6	16.5	19.2	21.7	12.7	15.1
Machinery	42.6	12.9	13.1	16.3	16.5	13.7	16.5	19.2	23.0	16.4	16.2
Construction	13.8	11.0	10.8	16.1	21.3	17.9	21.3	24.7	28.5	18.4	19.6
Other	31.6	44.4	20.1	30.1	23.1	18.0	20.9	23.6	21.0	15.6	17.5
Total industrial demand	291.9	235.1	198.8	223.4	223.4	198.6	235.3	273.5	283.6	196.1	213.2
Total U.S. primary demand[2]	228.8	182.8	162.2	152.4	174.7	135.5	167.8	207.6	219.1	154.5	166.2

[1] Refined metal from domestic ores
[2] Industrial demand less secondary
[p] Preliminary

Source: U. S., Department of the Interior, Bureau of Mines, <u>Nickel-77</u>, by John D. Corrick, Mineral Commodity Profiles, MCP-4 (Washington, D. C.: Government Printing Office), p. 11.

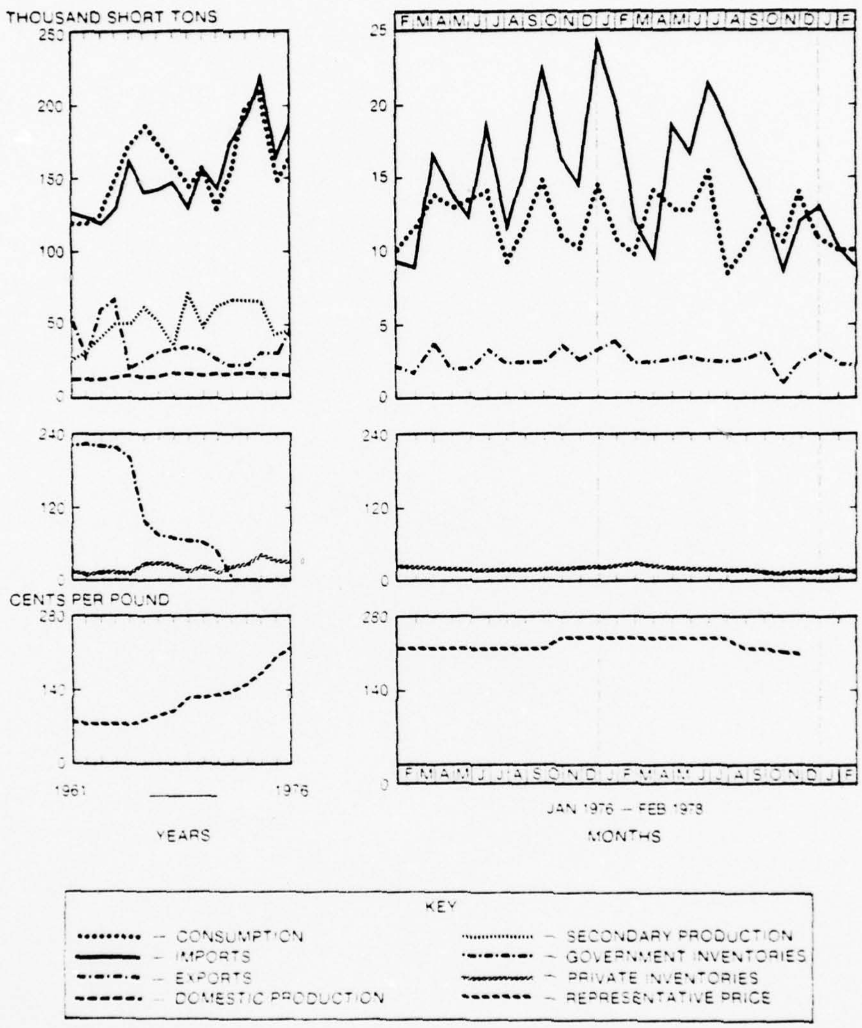


Figure 10

Nickel Data, 1961-78

Source: U. S., Department of the Interior, Bureau of Mines, Minerals and Materials/A Monthly Survey (January 1978), p. 18.

for approximately 7 percent of the imports in 1975. The flow of supply-demand for that year is shown in Figure 11.

Another important component of the United States nickel supply is the recycling of scrap. Over the ten-year period of 1967 to 1976, the average annual contribution of scrap to industrial demand was 24 percent (see Table 9). This scrap is generated in primary processing and fabricating plants, and from obsolete consumer goods made from nickel bearing materials.

Substitutes

Alternate materials can take the place of nickel in essentially all of its uses, but there are few exceptions where the use of these substitutes would not increase cost or result in the sacrifice of the desired physical or chemical characteristics. The largest area of substitution is where nickel-bearing material is used for its corrosion resistance, high strength, or special magnetic and electronic properties. For example, plastics have equal or superior corrosion resistance as compared to nickel-bearing corrosion resistant materials. Some alternate materials for nickel in its applications as alloys, castings, and catalysts are cobalt, chromium, manganese, platinum, columbium, and vanadium, but all of these substitutes are also on the critical materials list.

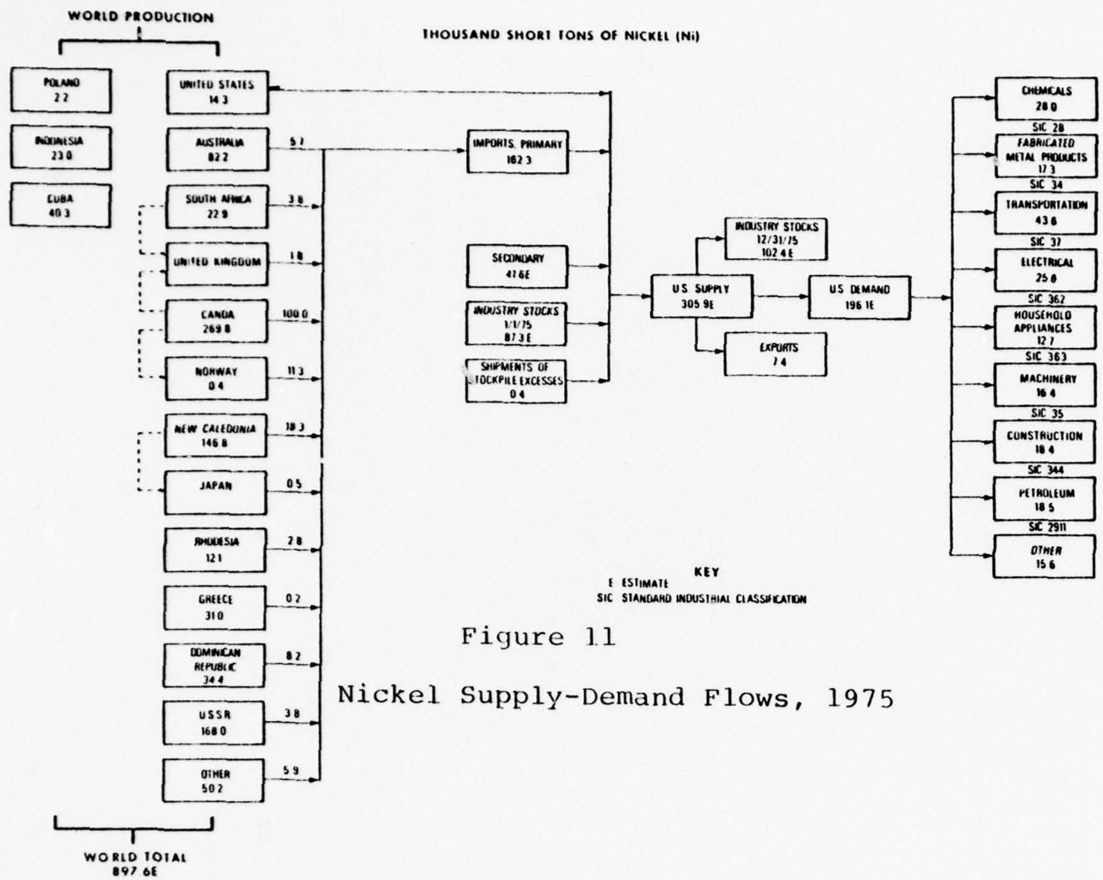


Figure 11

Nickel Supply-Demand Flows, 1975

Source: U. S., Department of the Interior, Bureau of Mines, Nickel-77, by John D. Corrick, Mineral Commodity Profiles, MCP-4 (Washington, D. C.: Government Printing Office, 1977), p. 10.

Economic Factors

Over a 23 year period from 1954 to 1976, the constant-dollar price of nickel remained relatively stable until the Canadian nickel strike in 1969. Since then, prices in general have been on a gradual increase, keeping slightly ahead of inflation but reflecting affects of increased energy costs (see Figure 10). For example, a 10 percent increase in the price of fuel oil, used extensively in nickel ore processing, will result in a corresponding increase of 7 cents per pound of nickel produced. Nickel also is considered to have a high income elasticity of demand. This relates to the fact that nickel is consumed principally in capital goods and durable goods, which become delayed purchases during a depressed economy. This results in a nickel demand that is sensitive to the business cycle.

Future Trends in Demand-Supply

The probable demand for the United States in 2000 will be 580 thousand tons of nickel which is an average annual growth rate of 3.1 percent for 1975 to 2000. The rest of the world demand is forecast at 1.63 million tons of nickel for a growth rate of 3.8 percent for the same period.

The United States cumulative primary demand over the forecast period is expected to be 7.4 million tons.

Domestically produced nickel has usually provided approximately 10 percent of the annual consumption. Based on this trend and future demand projections, cumulative domestic production between 1975 and 2000 would have to total 502,000 tons. However, the potential supply from domestic reserves is estimated at only 200,000 tons. This would result in a early depletion of domestic reserves unless there is a marked improvement over current technology in recovering nickel from low-grade ores.

The rest of the world cumulative primary demand for the forecast period is 22 million tons, which brings the total world primary demand to 29.4 million tons. The world's nickel reserves of 60 million tons are adequate to meet the projected demand at a ratio of 2.1.

Strategic Considerations

The use of nickel increases in times of war at a rate much faster than the growth of the overall economy. Imports provide a significant portion of the supply, but most is shipped overland from Canada. However, Canadian production is currently operating at 90 percent capacity with no projected increase in the near future. The United States probable 1985 demand would require 88 percent of Canada's total forecast capacity. Currently, the United States consumes only one-third of the Canadian capacity. The remainder of foreign shipments would be subject to

the normal hazards of wartime ocean shipping. This could result in a supply shortage if imports from Canada were the only available foreign source.[36]

Potential for Cartel-Like Action to Restrict Supplies and Raise Prices

The potential for cartel-like action to restrict supplies or raise prices is limited. Prices appear to have already reached the profit maximizing levels of cartels. Therefore, any formal cartel for producers would not likely change the current pricing strategy to any extent. Moreover, any market sharing agreements by a cartel would be both unstable and difficult with the possibility of new producers such as seabed nodule production which would probably result in price declines.[37]

Platinum - Group Metals

Uses and Importance in United States Industry

The platimum-group metals are used in industry for their extraordinary catalytic activity, chemical inertness over wide temperature ranges, and high melting points. Usually, a combination of these characteristics rather than a single one make the platinum-group indispensable in the chemical, petroleum-refining, automotive, electrical, glass, and medical-dental industries.

The chemical industry uses the metals as catalysts in the manufacture of a wide range of chemicals and

pharmaceuticals, and in laboratory and processing equipment where high corrosive environments are encountered.

Catalysts of the platinum-group are employed in petroleum refining mainly to upgrade the octane rating of gasolines. They are also important in the production of benzene, toluene, and xylene for chemical use; and in hydrocracking and isomerization. In 1974, the automotive industry became the largest purchaser of platinum and an important purchaser of palladium when they were used for the first time as catalysts to oxidize carbon monoxide and unburned hydrocarbon pollutants in engine exhaust gases.

In the electrical industry, this group of metals is important to prolonged functioning of electronic devices such as telephone exchange relays, voltage regulators, meters, thermostats, thermocouples, electron tubes, printed circuits, resistors, and various instruments.

Platinum-group metals are used in medicine in such devices as cautery points, hypodermic needles, and implanted cardiac pacemakers. A minor but important use of platinum-group metals is in brazing alloys for jet engines.[38] Major end uses for platinum-group metals in 1975 were automotive, 41 percent; chemical, 16 percent; electrical, 15 percent; and others, 28 percent.[39]

Areal Distribution and Production

The platinum-group consists of six closely related metals: platinum, palladium, rhodium, iridium, ruthenium, and osmium, of which the first three are more important to industry. World reserves as a group total 561 million troy ounces with an additional 573 to 1253 million troy ounces in resources as shown in Table 10. Approximately 98 percent of the identified reserves are located in the Republic of South Africa and the U.S.S.R. with the former controlling 83 percent of the platinum and the latter 52 percent of the palladium and 82 percent of the rhodium. Canada has 10 million troy ounces of platinum-group metal reserves, but these are virtually all by-products of nickel mining.

Domestic resources of the group are sizeable, 209 million troy ounces, located almost entirely in Alaska and Montana. However, reserves are only approximately 1 million troy ounces which are mainly by-product platinum-group metals in copper reserves located in the Western States.[40]

World mine production for platinum-group metals in 1976 totaled 5.94 million troy ounces with 91 percent being produced in almost equal shares by the Republic of South Africa and the U.S.S.R. Canada contributed 8 percent while domestic mines produced only .3 percent of

Table 10

World Platinum-Group Metals Resources[1]

(Million troy ounces)

	Reserves				Other platinum-group resources	Total platinum-group resources
	Platinum	Palladium	Rhodium	Platinum-group		
North America						
United States	NA	NA	NA	1	209	210
Canada	4.3	4.3	0.3	10	10	20
South America: Colombia	(2)	....	....	(2)	4	4
Asia: U.S.S.R.	45	90	3	150	NA	NA
Africa						
Republic of South Africa	248	100	14	400	250-930	650-1,330
Rhodesia	NA	NA	NA	NA	100	100
World total	> 297	> 194	> 17	561	[3] 573-1,253	984-1,664

NA Not available.

[1] Excludes undiscovered resources, except in the United States and Africa. Resources are known to exist in Australia, Ethiopia, Finland, and the Philippine Republic but have not been estimated.

[2] Less than 1 unit.

[3] Excludes Asia.

Source: U. S., Department of the Interior, Bureau of Mines, Platinum-Group Metals, by W. C. Butterman, Preprint from Bulletin 667, Mineral Facts and Problems (Washington, D. C.: Government Printing Office, 1975), p. 5.

the total.[41]

Supply-Demand Relationships

United States industrial demand for platinum-group metals in 1976 was 1.7 million troy ounces which represents approximately 29 percent of the total world primary production for that year.[42] The supply requirements of the United States are met by domestic production, imports, secondary production, and industry stocks. The components of supply and the demand patterns for the platinum-group during 1964 to 1974 and its three most important metals during 1966 to 1975 are shown in Tables 11 through 14. Figure 12 graphically presents data for the period 1961 to 1977.

Domestic production has only provided an average of 1.7 percent of the industrial demand over the period 1964 to 1974, while imports have historically been the largest component of supply (see Table 11). The net import reliance as a percent of apparent consumption for selected years is:[43]

1950	1955	1960	1965	1970	1971
74%	91%	82%	87%	78%	75%

1972	1973	1974	1975	1976	1977
82%	87%	87%	83%	92%	92%

The major import sources for the group from 1972

Table 11

Platinum-Group Metals Supply-Demand Relationships, 1964-74

(Thousand troy ounces)

	1964	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974
World mine production:											
United States	40	35	51	16	15	22	17	18	17	20	13
Rest of world	2,506	2,934	3,004	3,159	3,379	3,409	4,222	4,066	4,202	5,154	5,747
Total	2,546	2,969	3,055	3,175	3,394	3,431	4,239	4,084	4,219	5,174	5,760
Components of U.S. supply:											
Refinery production, domestic ores	44	38	53	16	11	18	20	21	15	20	13
Imports	888	1,193	1,379	1,363	1,837	1,299	1,532	1,368	1,892	2,504	3,241
Secondary refined	120	109	103	366	329	372	350	278	256	266	325
Reported industry stock, Jan. 1	700	767	893	1,068	864	1,091	1,068	710	797	931	1,033
Government releases	....	....	316	2	....	9	3	....	....	....	....
Total U.S. supply	1,752	2,107	2,744	2,815	3,041	2,789	2,973	2,397	2,960	3,721	4,612
Distribution of U.S. supply:											
Reported industry stock, Dec. 31	767	893	1,068	864	1,091	1,068	710	797	931	1,033	1,137
Government acquisitions	....	....	100	117	95	35	168	8	....	....	....
Exports	146	103	205	280	395	501	414	405	539	628	836
Industrial demand	1,050	1,188	1,709	1,211	1,296	1,360	1,331	1,262	1,562	1,831	1,981
Apparent surplus (+), deficit (-)	-211	-77	-338	+343	+164	-175	+350	-75	-72	+229	+658
U.S. demand pattern:											
Automotive*	....	....	....	....	....	....	....	....	....	....	500
Chemicals	274	308	435	380	406	424	380	389	589	573	427
Petroleum refining	87	120	266	127	113	67	160	141	130	144	166
Ceramics and glass	74	32	126	57	55	78	75	45	43	91	92
Electrical	466	551	661	440	461	558	546	499	536	666	551
Dental supplies	70	77	94	82	88	76	68	86	126	164	151
Jewelry and arts	64	65	85	65	72	68	57	49	50	61	58
Other	15	35	42	60	101	89	45	53	88	132	36
Total demand	1,050	1,188	1,709	1,211	1,296	1,360	1,331	1,262	1,562	1,831	1,981
U.S. primary demand (total demand minus secondary refined)	930	1,079	1,606	845	967	988	981	984	1,306	1,565	1,656

*Estimated

Source: U. S., Department of the Interior, Bureau of Mines, Platinum-Group Metals, by W. C. Butterman, Preprint from Bulletin 667, Mineral Facts and Problems (Washington, D. C.: Government Printing Office, 1975), p. 8.

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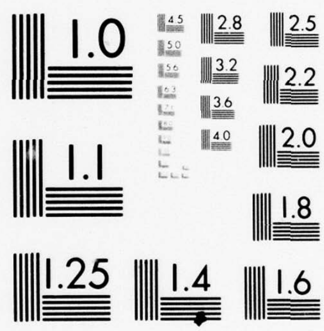

MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS-1963-A

Table 12

Platinum Supply-Demand Relationships, 1966-75

(Thousand troy ounces)

	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975
World production										
United States	18	7	7	11	8	8	5	6	4	6
Rest of world	1,213	1,277	1,363	1,392	1,831	1,700	1,780	2,359	2,699	2,612
Total	1,231	1,284	1,370	1,403	1,839	1,708	1,785	2,365	2,703	2,618
Components of U S supply										
Primary refined	125	134	150	177	191	167	58	38	20	20
Imports refined metal	340	346	418	379	540	492	673	886	1,363	961
Secondary refined	50	126	116	127	118	103	76	95	96	104
Industry stocks Jan 1	389	398	323	305	361	292	386	427	447	533
Shipments of Government stockpile excesses	314	2	...	...	...	...	...	...	...	...
Total U S supply	1,218	1,006	1,007	988	1,210	1,054	1,193	1,446	1,926	1,618
Distribution of U S supply										
Industry stocks Dec 31	398	323	305	361	292	386	427	447	533	591
Government acquisitions						3		...	...	...
Exports	102	162	223	224	226	241	346	381	401	328
Demand	724	511	509	517	509	427	545	658	944	699
Apparent surplus (+), deficit (-)	6	-10	30	114	-183	3	125	40	-48	...
U S demand pattern										
Automotive *									350	273
Chemicals	191	159	158	175	148	135	226	239	216	149
Petroleum refining	235	123	90	62	145	137	99	124	139	108
Ceramics and glass	91	45	48	63	47	41	27	72	74	34
Electrical	117	100	117	112	103	52	92	117	99	74
Dental supplies	24	25	25	22	18	23	30	28	26	17
Jewelry and arts	41	33	40	36	29	19	21	22	23	23
Other	25	26	31	47	19	20	50	56	17	21
Total demand	724	511	509	517	509	427	545	658	944	699
Total U S primary demand (total demand minus secondary refined)	674	385	393	390	391	324	469	563	848	595

*Estimated

Source: U. S., Department of the Interior, Bureau of Mines, Minerals in the U. S. Economy: Ten-Year Supply-Demand Profiles for Mineral and Fuel Commodities (1966-75), p. 66.

Table 13

Palladium Supply-Demand Relationships, 1966-75

(Thousand troy ounces)

	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975
World production										
United States	29	8	7	10	10	10	11	13	9	13
Rest of world	1,451	1,522	1,625	1,634	1,903	1,899	1,943	2,200	2,374	2,413
Total	1,480	1,530	1,632	1,644	1,913	1,909	1,954	2,213	2,383	2,426
Components of U S supply										
Primary refined	70	54	64	77	85	77	35	17	11	13
Imports refined metal	909	749	1,183	652	811	684	927	1,170	1,405	573
Secondary refined	50	215	196	228	209	161	163	150	213	150
Industry stocks, Jan 1	427	575	461	394	609	333	316	406	493	478
Total U S supply	1,456	1,593	1,904	1,351	1,714	1,255	1,441	1,743	2,122	1,214
Distribution of U S supply										
Industry stocks, Dec 31	575	461	394	609	333	316	406	493	478	374
Government acquisitions	100	117	95	32	168	5				
Exports	93	106	155	250	168	146	173	221	390	298
Demand	894	621	722	759	739	760	876	1,012	886	542
Apparent surplus (+), deficit (-)	206	-288	-538	299	-306	-28	14	-17	-368	
U S demand pattern										
Automotive *									150	97
Chemicals	222	192	228	215	165	219	293	260	163	143
Petroleum refining	29	3	23	1	15	3	15	4	15	(1)
Electrical	531	325	329	430	429	431	425	524	390	132
Dental supplies	67	56	62	52	48	61	94	135	124	115
Jewelry and arts	32	19	18	22	17	19	19	23	22	23
Other	13	26	62	39	45	27	30	66	22	32
Total demand	894	621	722	759	739	760	876	1,012	886	542
Total U S primary demand (total demand minus secondary refined)	844	406	526	531	530	599	713	862	673	392

*Estimate
[1] Included in other

Source: U. S. Department of the Interior, Bureau of Mines, Minerals in the U. S. Economy: Ten-Year Supply-Demand Profiles for Mineral and Fuel Commodities (1966-75), p. 61.

Table 14

Rhodium Supply-Demand Relationships, 1966-75

(Thousand troy ounces)

	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975
World production										
United States										
Rest of world	76	79	85	86	112	105	109	141	161	157
Total	76	79	85	86	112	105	109	141	161	157
Components of U.S. supply										
Primary refined	10	5	7	8	9	8	3			
Imports, refined metal	66	49	73	43	44	37	56	101	110	91
Secondary refined	2	12	12	12	13	9	11	12	11	14
Industry stocks, Jan. 1	45	58	47	55	56	48	52	57	52	56
Shipments of Government stockpile excesses	1									
Total U.S. supply	124	124	139	118	122	102	122	170	173	161
Distribution of U.S. supply										
Industry stocks, Dec. 31	58	47	55	56	48	52	57	52	56	103
Exports	6	7	10	17	11	10	11	15	27	21
Industrial demand	70	55	45	50	49	34	46	74	62	37
Apparent surplus (+), deficit (-)	10	-15	-29	5	-14	-6	-8	-29	-28	
U.S. demand pattern										
Chemicals	14	18	15	18	26	15	15	24	24	16
Ceramics and glass	35	11	7	11	7	3	14	17	7	4
Electrical	9	12	10	11	9	9	8	13	16	8
Jewelry and arts	9	9	7	6	5	5	7	12	10	5
Other	3	5	6	4	2	2	2	8	5	4
Total demand	70	55	45	50	49	34	46	74	62	37
Total U.S. primary demand (total demand minus secondary refined)	68	43	33	38	36	25	35	62	51	23

Source: U. S. Department of the Interior, Bureau of Mines, Minerals in the U. S. Economy: Ten-Year Profiles for Mineral and Fuel Commodities (1966-75), p. 72.

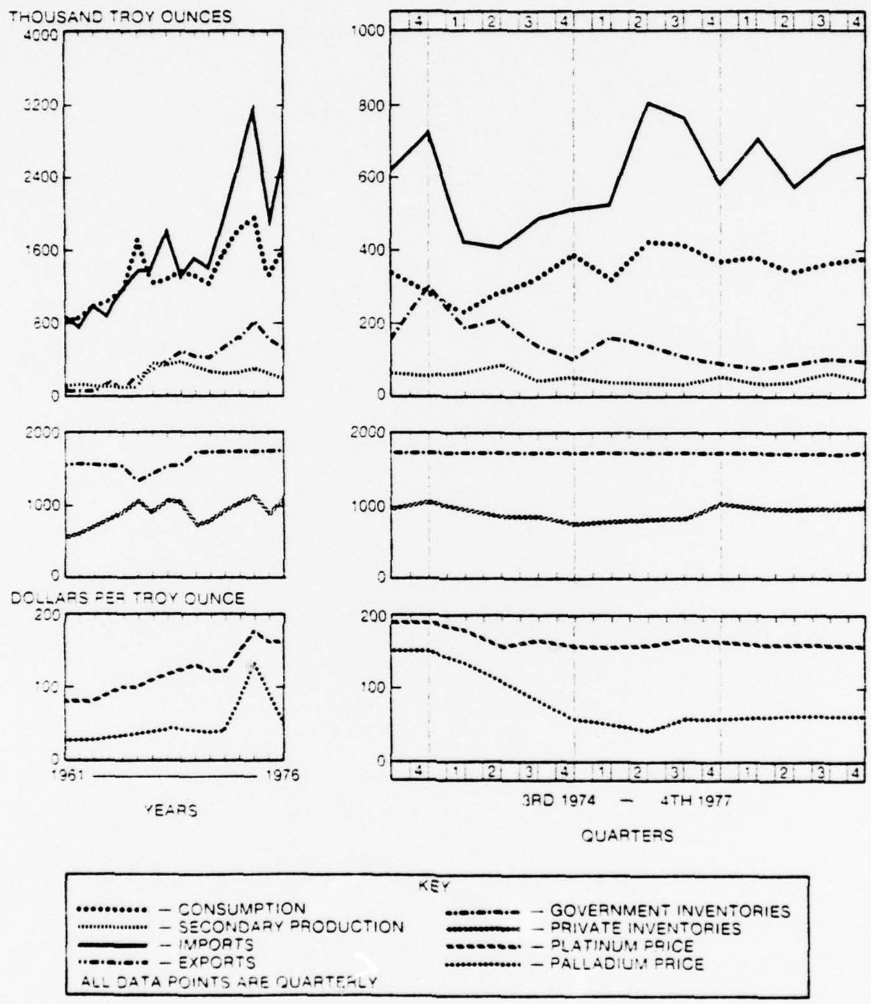

Figure 12

Platinum-Group Metals Data, 1971-77

Source: U. S., Department of the Interior, Bureau of Mines, Minerals and Materials/A Monthly Survey (January 1978), p. 36.

to 1975 were U. S.S.R., 31 percent; United Kingdom, 26 percent; Republic of South Africa, 25 percent; and others, 18 percent.[44] The flow of the supply and demand for platinum, palladium, and rhodium in 1975 is shown in Figures 13 through 15.

Recycling of the platinum-group metals has been an important supply component by providing an annual average of 18 percent of the domestic industrial demand during 1964 to 1974. This secondary production is made possible because these metals are virtually indestructible and their high cost insures that every effort will be made for recovery.[45]

Substitutes

Platinum-group metals are employed only where well justified for technical and economic reasons because of their high prices. The main disadvantage of substitution is the higher cost of a shorter useful life or some contamination of the product. Additionally, the list of possible substitutes contains many of those materials considered to be critical: nickel, cobalt, chromium, vanadium and tungsten.

Economic Factors

South African producers control the price at which most platinum is sold while the U. S.S.R. has effective control over the price of palladium. The time price

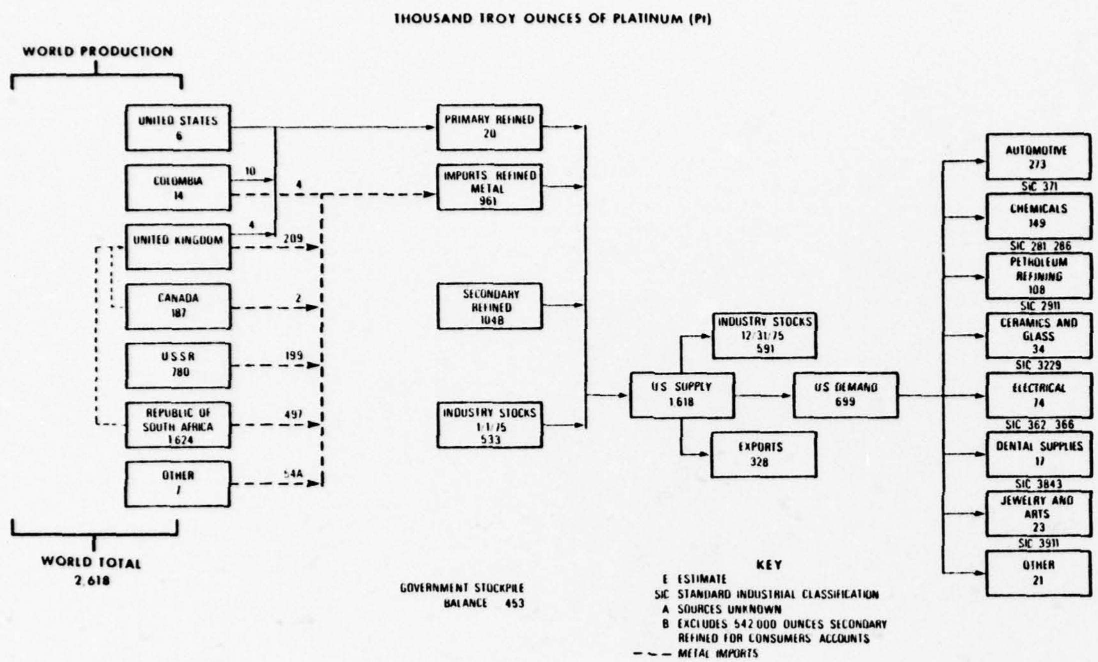

Figure 13

Platinum Supply-Demand Flows, 1975

Source: U. S., Department of the Interior, Bureau of Mines, Minerals in the U. S. Economy: Ten Year Supply-Demand Profiles for Mineral and Fuel Commodities (1966-75), p. 66.

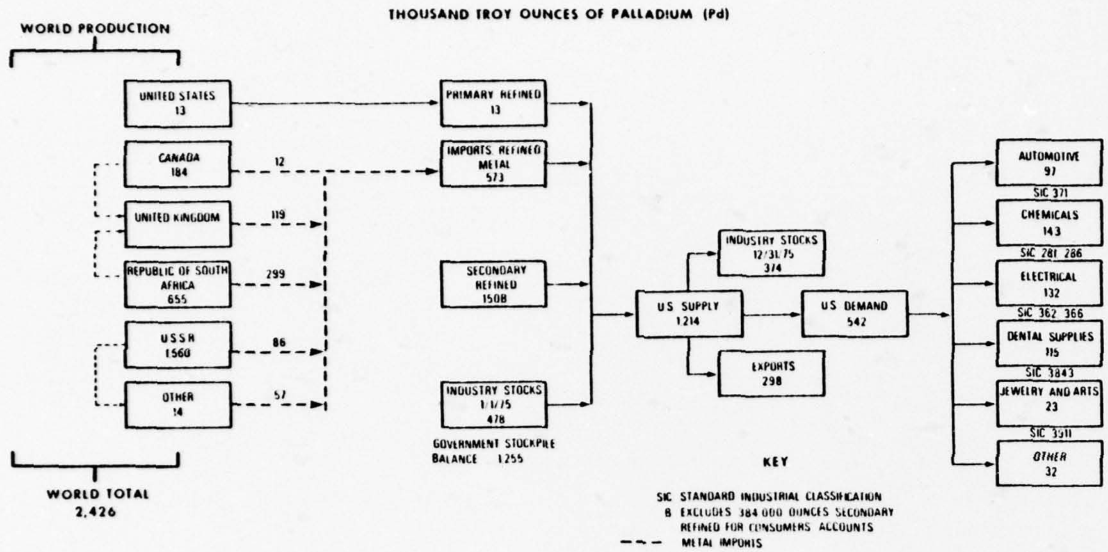

Figure 14

Palladium Supply-Demand Flows, 1975

Source: U. S., Department of the Interior, Bureau of Mines, Minerals in the U.S. Economy: Ten-Year Supply-Demand Profiles for Mineral and Fuel Commodities (1966-75), p. 61.

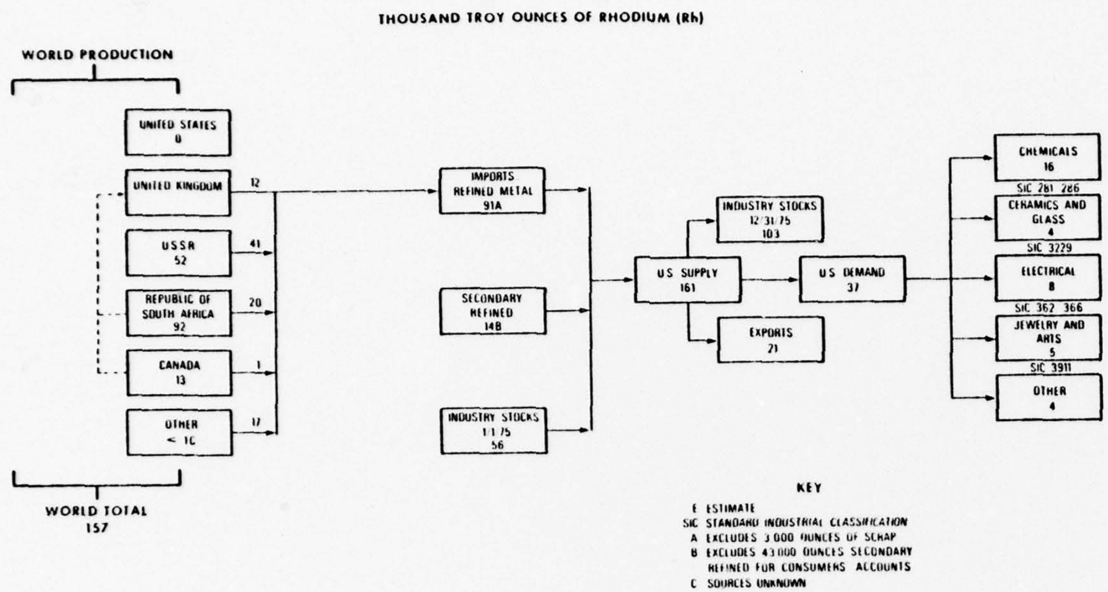

Figure 15

Rhodium Supply-Demand Flows, 1975

Source: U. S., Department of the Interior, Bureau of Mines, Minerals in the U. S. Economy: Ten Year Supply-Demand Profiles for Mineral and Fuel Commodities (1966-75), p. 72.

relationships in terms of constant dollars indicates a relative stability of platinum and rhodium over the past two decades. Palladium has shown a relatively deflated price with a gradual annual increase except in 1973 and 1974 when it rose sharply but declined in 1975 and stabilized through 1977.

Future Trends in Demand-Supply

Probable primary demand in 2000 for the United States will be 2.94 million troy ounces of platinum-group metals which is an annual growth rate of 2.8 percent. The rest of the world is forecast at 8.08 million troy ounces based on an annual growth rate of 3 percent.

Cumulative domestic primary demand from 1973 to 2000 for the group is expected to be 55 million troy ounces with United States mine production supplying only a fraction of 1 percent. The rest of the world is forecast to have a cumulative primary demand of 151 million troy ounces. World reserves of 561 million troy ounces of platinum-group metals are adequate to meet the world cumulative primary demand of 206 million troy ounces. The ratio of recoverable reserves to cumulative demand for platinum, palladium, and rhodium in 2000 are 3.1, 2.4, and 2.8 respectively.

Strategic Considerations

Although world resources of platinum-group metals are large and supplies ample, 93 percent comes from two countries: The Republic of South Africa and the U.S.S.R. Also, each is the major producer of one of the more important metals. The Republic of South Africa produces approximately two-thirds of all the platinum while the U.S.S.R. produces the same share of all the palladium. Canada is the only other major industrialized nation with adequate domestic supplies of the platinum-group metals. Since the United States normally consumes one-fourth to one-third of the world mine production with domestic reserves providing only a fraction of 1 percent of the nation's demand, reliance on foreign sources will continue.

Potential for Cartel-Like Action to Restrict Supplies Or Raise Prices

The potential for cartel-like action in platinum-group metals is fairly high. There are only five significant producers operating in three countries. There is, however, evidence that platinum is already priced at or near optimum levels. Producers appear to withhold stocks from the market despite marginal costs of production, believed to be only half or less of recent market prices. The major producers have for many years supported a stable producer price and have admitted to holding down prices to

prevent more intensive efforts to develop platinum substitutes. Although a potential for further price increases does exist, it appears from the history of the industry that producers are sensitive to the market needs and have a willingness to fill them at current prices.[47]

FOOTNOTES

[1]A detailed explanation of the mission of the Department of Interior is in U.S., Department of the Interior, Bureau of Mines, Draft of Strategic and Tactical Plan (January 1976), pp. I-3-25.

[2]U. S., Department of the Interior, Bureau of Mines, Chromium-1977, by John L. Morning, Mineral Commodity Profiles, MCP-1 (Washington, D. C.: Government Printing Office, 1977), pp. 1, 4.

[3]Ibid., pp. 2, 4-6.

[4]See U. S., Department of the Interior, Annual Report of the Secretary of the Interior Under the Mining and Minerals Policy Act of 1970 for 1977, p. 24; U. S., Department of the Interior, Bureau of Mines, Minerals and Materials/A Monthly Survey (December 1977), p. 12; and U. S., Department of the Interior, Bureau of Mines, Minerals and Materials/A Monthly Survey (January 1978), p. 6.

[5]Bureau of Mines, Chromium-1977, pp. 7-8.

[6]U. S. Army War College, Strategic Studies Institute, Materials and the New Dimensions of Conflict, revised ed., by Alwyn H. King and John R. Cameron, Military Issues Research Memorandum, MIRM 74-10-R (Carlisle Barracks, PA: U. S. Army War College, 1974), p. 7.

[7]The problems caused by this activity are discussed in Roger LeRoy Miller, The Economic Impact of U. S. Restrictions on Trade With Rhodesia (Coral Gables, Florida: University of Miami, 1974).

[8]The ratio of recoverable reserves to cumulative demand for most all minerals is in U. S., Department of the Interior, Bureau of Mines, Mineral Trends and Forecasts (October 1976), p. 11.

[9]Bureau of Mines, Chromium-1977, pp. 9-13.

[10] U. S., Executive Office of the President, Council on International Economic Policy, Special Report: Critical Imported Materials (December 1974), p. A-9.

[11]U. S., Department of the Interior, Bureau of Mines, Cobalt-77, by Scott F. Sibley, Mineral Commodity Profiles, MCP-5 (Washington, D. C.: Government Printing Office, 1977), p. 1.

[12]U. S., Department of the Interior, Bureau of Mines, Commodity Data Summaries, 1977, p. 42.

[13]Bureau of Mines, Cobalt-77, pp. 5-6.

[14]Allen L. Hammond,"Manganese Nodules (II): Prospects for Deep Sea Mining," Science (15 February 1974): 644.

[15]Bureau of Mines, Cobalt-77, p. 4.

[16]See Department of the Interior, Annual Report of Secretary for 1977, p. 24, Bureau of Mines, Minerals and Materials (December 1977), p. 12; and Bureau of Mines, Minerals and Materials (January 1978), p. 6.

[17]Bureau of Mines, Cobalt-77, pp. 8-17.

[18]Executive Office of President, Critical Materials, p. A-43.

[19]U. S., Department of the Interior, Bureau of Mines, Manganese-77, by Gilbert L. DeHuff and Thomas S. Jones, Mineral Commodity Profiles, MCP-7 (Washington, D. C.: Government Printing Office, 1977), pp. 6-8.

[20]Hammond, Manganese Nodules: 644.

[21]Bureau of Mines, Manganese-77, p. 7.

[22]Ibid., p. 3.

[23]See Department of the Interior, Annual Report of Secretary for 1977, p. 24; Bureau of Mines, Minerals and Materials (December 1977), p. 12; and Bureau of Mines, Minerals and Materials (January 1978), p. 6.

[24]Bureau of Mines, Commodity, 1977, p. 98.

[25]Bureau of Mines, Manganese-77, p. 3.

[26]Ibid., p. 18.

[27]Ibid., pp. 11-16.

[28]Executive Office of the President, Critical Materials, pp. A-30-31.

[29]U. S., Department of the Interior, Bureau of Mines, Nickel-77, by John D. Corrick, Mineral Commodity

Profiles, MCP-4 (Washington, D. C.: Government Printing Office, 1977), p. 5.

[30]Bureau of Mines, Commodity, 1977, p. 112.

[31]Bureau of Mines, Nickel-77, p. 1.

[32]Ibid., p. 6.

[33]Ibid., p. 3.

[34]See Department of the Interior, Annual Report of Secretary for 1977, p. 24; Bureau of Mines, Minerals and Materials (December 1977), p. 12; and Bureau of Mines, Minerals and Materials (January 1978), p. 6.

[35]Bureau of Mines, Commodity, 1977, p. 112.

[36]Bureau of Mines, Nickel-77, pp. 9-17.

[37]Executive Office of the President, Critical Materials, p. A-23.

[38]U. S., Department of the Interior, Bureau of Mines, Platinum-Group Metals, by W. C. Butterman, Preprint from Bulletin 667, Mineral Facts and Problems (Washington, D. C.: Government Printing Office, 1975), pp. 4-5.

[39]Bureau of Mines, Commodity, 1977, p. 126.

[40]Bureau of Mines, Platinum-Group Metals, p. 5.

[41]Ibid., pp. 2-3.

[42]Bureau of Mines, Commodity, 1977, p. 126.

[43]See Department of the Interior, Annual Report of Secretary for 1977, p. 24; Bureau of Mines, Minerals and Materials (December 1977), p. 12; and Minerals and Materials (January 1978), p. 6.

[44]Bureau of Mines, Commodity, 1977, p. 126.

[45]Bureau of Mines, Platinum-Group Metals, p. 8.

[46]Ibid., pp. 12-20.

[47]Executive Office of the President, Critical Materials, p. A-14.

CHAPTER IV

UNITED STATES MINERALS POLICY: PROBLEMS AND POSSIBLE SOLUTIONS

In view of the fact that the Nation is not totally self sufficient in minerals, that consumption rates are increasing and competition for limited supplies is on the rise, and that the reliance on foreign producers for many important minerals is high, the establishment of comprehensive policy to insure the sustained supply of minerals at reasonable prices is necessary.

The broad goals for such a policy should be the intelligent exploration for and development of domestic resources, and the reciprocal participation in international trade. Both goals must be subject to certain constraints, such as national security, economic and social well-being of the nation as a whole, and international consciousness.[1] However, recent events with non-fuel minerals point to the conclusion that such a comprehensive policy does not exist for the United States.

The short-run imbalances in the supply and demand of minerals, and the dramatic rise in commodity prices have been disruptive and costly. There also exists a high possibility that these problems could reoccur, because of the supply-demand characteristics of minerals.[2] Consequently, current mineral policy must be reviewed in order

to identify problem areas and possible solutions.

Current Policy and Problems

The current guidance for United States minerals policy is contained in two legislative acts, the National Materials Policy Act of 1970, and the Mining and Minerals Policy Act of 1970.

In October 1970, the National Materials Policy Act of 1970 was established. The stated purpose of this act is:

> to enhance environmental quality and conserve materials by developing a national materials policy to utilize present resources and technology more efficiently, to anticipate the future materials requirements of the Nation and the world, and to make recommendations of the supply, use, recovery, and disposal of materials.[3]

Pursuant to this act, the National Commission on Materials Policy was formed to investigate and make recommendations for the purpose of developing a national materials policy.[4] The Commission's final report was filed in June 1973.[5] The major theme being the necessity to strike a balance between the need for the production of goods and the need to protect the environment, along with the need for a balance between the supply of materials and the demand for their use. To achieve this goal, the Commission recommended conservation, recycling, and greater efficiency.

In the area of import reliance, the Commission specifically recommended that market forces should be the prime determinant of the mix of imports and domestic production.[6] However:

> If dangerous or costly reliance upon imported materials appears to be the consequence of existing trends, public policy must intervene when considerations of national security, the health and viability of domestic materials industry, and fair international competition, enter into the determination of when to rely upon the market and when to modify its operation.[7]

The second piece of legislation is the Mining and Minerals Policy Act of 1970,[8] which was originated by the National Commission on Materials Policy.[9] This act states that it is the continuing policy of the Federal Government to foster and encourage private enterprise in the development and efficient use of the domestic resources,[10] thereby inferring the reduction of the United States' reliance on imports of non-fuel minerals. The responsible agency named for carrying out this act is the Department of the Interior.

The effects of these two legislative acts have recently come under severe criticism by some Federal agencies and members of Congress.[11] The attack is based on the inability of formulated policy to deal with immediate problems and the inaction or vagueness of responsible agencies.

In a report by the Congressional Budget Office,

the expressed opinion of the National Materials Policy Act of 1970, is that its only consequence was the formation of the National Commission on Materials Policy, which has contributed nothing to solving the immediate concern of short-term interruptions in supplies. Rather, the Commission devoted its attention mainly to the longer-term concerns of material availability and environmental quality.[12]

The General Accounting Office reported to Congress, expressing concern over the lack of decisive action by the Department of Interior in carrying out the directives set forth by the Mining and Mineral Policy Act of 1970.[13] Regardless of the general nature of the wording, it was expected that questions would be answered such as the permissible degree of foreign supply dependence, imports and exports of minerals, emergency stockpiling, taxation, environmental quality, and the Nation's capability to supply domestic needs. The policy was in general terms, recognizing the need for continued scrutiny and flexibility in order to respond to changes in demand, economics, security, and environmental requirements.[14] The immediate response by the Department of Interior on this matter was that the Act only restated traditional policy goals, as set forth by the Organic Act of 1910, and provided no new authority or specific funding. Additionally, there are potential conflicts between the stated minerals policy and other National objectives.[15] Numerous agencies and departments

were said to be conducting programs whose goals inhibit or hinder domestic minerals production.[16]

The Secretary of the Interior, in a 1977 annual report, perhaps in response to the above criticism, presented a somewhat realigned minerals policy. In general, the national mining and minerals policy encourages the development of mineral resources to assist in maximizing the long-run standard of living of United States citizens. This goal is said to be achieved when American consumers obtain the desired materials at the lowest possible private and social costs. These costs will include those for environmental protection and the security against sudden cutoff of foreign supplies. The normal competitive operations of the marketplace, including domestic and foreign competitive forces, would serve the goal in determining the acceptable level of imports, except for security reasons. Therefore, United States policy would be implemented by minimizing government interference or any other intervention in the marketplace.

The potential for the marketplace to cease functioning in an acceptable manner is present in producer organizations, cartels, and monopolists, of minerals, but such an action equal to the 1973 oil cartel is not likely. The costs to the Government, or reduction in the standard of living, should such action occur, would be greatest when a particular mineral has a large import reliance,

when it is used extensively in the economy, and when the United States is less able to operate without it.[17]

It appears that this somewhat realigned policy statement does not differ much from the effects of the previous two legislative acts. Therefore, if the criticism by the Congressional Budget Office is correct, even with this recent policy statement, nothing is being done to deal with immediate problems and the minerals policy is effectively left at the traditional level.

Traditional policy is aimed at protecting the Nation's industry from major interruptions in the physical flow of raw materials. These interruptions are generally envisioned as arising from the hostile actions of war or embargoes against the United States. The policy to guard against such threats is simple. Domestic production is encouraged for some materials and conservation on others. Where economic self-sufficiency is unattainable, a stockpile of the material could be accumulated in sufficient quantities to meet the anticipated duration of the interruption and be released only in the event of national emergencies where defense production is threatened. The Strategic and Critical Materials Stockpiling Act of 1946, is the basic authority for such actions. The materials selection is based on those materials imported that could be denied in wartime. Also, it is assumed that the circumstances requiring the release of these materials will

be clear, such as wars and embargoes. These stocks are not to be used during the less clearly defined economic fluctuations and most definitely are not allowed to interfere with the day-to-day workings of the market.

This traditional policy view is of course inadequate to deal with contemporary problems. The United States is currently dependent on foreign supplies of many materials and will probably become even more dependent in the future as the economy further grows and diversifies. Total self-sufficiency, at least within current technology, appears to be unattainable. Also, the likelihood of protracted war is very low. Future conflicts will most likely be limited wars, as was Vietnam, or of short duration. The lethality of the battlefield will be such that the military stocks of the combatants will be used or destroyed long before the raw materials on hand can be used for war production.[18]

Additionally, long-term supply interruptions as a result of producer organizations or political embargoes will be difficult in view of the many mechanisms that limit the producer's ability to sustain such action and attain the desired goal.[19]

The Nation and the world as a whole are faced with new problems. Long-term planning is essential for both the producer and consumer in a highly industrialized economy, characterized by enormous capital requirements and long

lead times. Unexpected changes can cause costly disruptions in plans underway and uncertainty of the future will discourage the expansion of production capacity.

These problems are already compounded by such things as changes in demand for the final product, caused by varying tastes in customer desires; variation in environmental protection standards; and technological advances that make old production methods non-competitive. When the short-run supply and demand disruptions and the violent fluctuations of commodity prices are added, the problem becomes extremely complex and international in scale. Many of the actions by the United States affect directly or indirectly the fragile economies of Western Europe and Japan. Likewise, anything that damages these economies is a threat to United States interests, because of our cultural and philosophical ties.[20]

The political considerations of policy are also quite complex. During a period of tight supplies, the industrial nations will find themselves competing with each other. Should independent solutions be sought, the broader goals of alliances may be hurt. Such action would form an obstacle to effective consumer blocks against events such as the 1973 oil embargo. Effort to coordinate commodity policies among developed countries will infringe on each nation's closely guarded prerogative to control its own economy. Also, democratic governments would find

it hard to comply to agreements if it meant higher prices at home.

Conflicts will also occur between the policy for the security of supplies and other broad goals. The cooperation with other developed countries will lead to government assisted programs that will end up in competition with American firms. Additionally, trade concessions with some producing countries could lead to embarrassing dependencies on governments whose ideals are objectionable to the United States.[21]

Possible Solutions

The problems of shortages and disruptions in the supply of minerals have both long and short-run policy implications; however, the latter is the most urgent. In the long-run, the mechanisms of economics and technology will most likely prevail. This does not mean, however, that the long-run implications are of no concern. Their sparse treatment in this paper does not mean that they can be ignored. Complacency on this matter could lead to a far worse situation for the United States and the world than perceived now. Continued monitoring and planning are required to prevent facing a minerals shortage situation in the future where time is an enemy rather than an ally.

There are many different proposed solutions to the problems of the Nation's minerals supply. Some are complex

and not all are appropriate in every case. Among the most frequently proposed are price controls, export restrictions, trade agreements, rationing and allocation schemes, development of alternate sources, and policies toward American firms.

The limitations of these solutions run contrary to the characteristics of the case study minerals in this paper. Generally, these solutions require a country to be nearly self-sufficient in the mineral or it must be produced or processed in a highly concentrated industry. The success of any trade agreements with producing nations will lie largely with their political ideologies and perceived notions of the character of the United States. For the communist world and non-democratic countries, the conflicting views are obvious. The less developed countries are still in the shadows of colonialism, imperialism, and gun boat diplomacy. Even though these are long past, the industrialized giants are still seen as villains and cannot be trusted. Additionally, some solutions will only aggravate other areas, offering no net gain.[22]

The National Commission on Supplies and Shortages,[23] among others, has indicated that the proper management of economic stockpiles, apart from strategic considerations, could be a universal antidote to offset the impact of

actual supply interruptions, to deter threats of price gouging by cartels or monopolists, and to have a stabilizing effect on commodity price fluctuations caused by cyclical volatility and short-run imbalances in supply-demand. As a policy instrument, the government could greatly reduce the severity of these problems by accumulating stocks when prices were low or supplies plentiful and releasing them when prices were high or supplies tight.[24]

Materials stockpiled to protect against curtailed imports as a result of political embargo, civil unrest within the producing country or its affects on neighboring states, or natural disaster, would be released only if the supplies were disrupted. Although examples are rare, the Canadian nickel mining strike and the cutoff of manganese and chromium by Russia, growing factors such as political unrest in Southern Africa, vulnerability of mining and transportation facilities to terrorist action, and the increasing politicalization of mineral supplies, make disruptions more likely in the future.

The choice as to which materials to include in such a stockpile might be those whose source was concentrated in regions with a possibility of widespread disorder and those outside the free world. Chromium, cobalt, manganese, and platinum-group metals were suggested. Quantities held would be determined on an individual

commodity basis using a sophisticated method, such as cost-benefit analysis. For illustrative purposes, one year's supply could be held. For the above four metals, the average total cost of imports over]973 to]975, was $650 million.

Regardless, economic stockpiling for this purpose would require relatively small quantities of only a few materials. Such stockpiling could also provide the much required time to develop new sources of supply and to adjust for the use of alternate materials.

Economic stockpiling to protect against threats of price gouging by cartels or monopolists would require a much more active policy, which would include materials whose prices could be manipulated by producer agreement or unilateral action. It is suggested that one year's supply of such material be held. A study by the Charles River Associates on the possibilities of cartel formation in several materials, including chromium and manganese, revealed that short-term cartel profit maximization would require a 25 percent cut in shipment to the United States. Such an action was found to be unlikely and even less likely to last four years, which would make one year's supply of stocks adequate. Additionally, any deterring effect that held stocks have on reducing the probability of price gouging, makes their costs more easily justified

and is an important factor in determining stockpile size.[25]

Economic stockpiling to stabilize price fluctuations caused by cyclical volatility might require active and continuous government intervention in the marketplace. Intervening actions would not eliminate fluctuations totally, but could adjust them to a desired level. Such a stockpile would contain as a minimum the amounts for the other types, along with a sufficient quantity of material to achieve price stabilization goals. A crude estimate of both the list and magnitude of materials would be difficult to make. The benefits, however, that could be accrued from commodity price stabilization would be the absence of inflation or deflation. Proper stockpiling actions could supplement the market when it was weak, raising prices and stimulating demand.[26]

There are, however, possible consequences with the use of economic stockpiling. Should its use mask the long-run price trends, important business signals would be lost. Price changes over the long-run provide input for important decisions on investment, material substitution, material research and development, and the allocation of mineral supplies.[27] Price changes caused by speculation are difficult to recognize and are short-lived. Stockpile transactions could come too late and increase the

reaction that follows a speculative rush. Speculative buying and selling could even be accelerated where large stockpiles were increased or decreased at unpredictable intervals.[28]

There are certain international implications also. A cartel-deterrence strategy could be inefficient, and even unworkable, in the absence of agreement and coordination on stockpile objectives and operating rules with other consuming nations. The United States would have a difficult time acting alone, particularly if her market share were small. If, however, the United States' stockpile had substantial influence over the world market, other countries might lose the incentive to accumulate holdings, leaving the United States in the position of financing commodity insurance policies for others.[29]

Regardless of these possible consequences, which are not all, economic stockpiling is a viable solution if managed correctly.[30] The National Commission on Supplies and Shortages has weighed potential costs and difficulties against the benefits and recognize economic stockpiling as a worthwhile form of insurance against actual supply interruptions and price gouging. It is the majority opinion of the Commissions' that in the case of commodity price fluctuations, the potential difficulties yet outweigh the potential benefits.[31]

FOOTNOTES

[1]See Sterling Brubaker, In Command of Tomorrow: Resource and Environmental Strategies for Americans (Baltimore: The Johns Hopkins University Press for Resources for the Future, Inc., 1975), pp. 96-97; David Novick, A World of Scarcities: Critical Issues in Public Policy (New York: Halsted Press, John Wiley and Sons, 1976), p. 13; and Yuan-li Wu, Raw Materials in a Multipolar World (New York: Crane, Russak and Co., 1973), pp. 48-49.

[2]For a detailed discussion of this matter, see Chapter II above.

[3]U. S., Congress, Public Law 91-512, National Materials Policy Act of 1970, 91st Cong., 26 October 1970, Statutes, 84:1234.

[4]Ibid.

[5]U. S., Congress, Senate, Committee on Interior Insular Affairs, Hearings Before a Subcommittee on Minerals, Materials, and Fuels, The Final Report of the National Commission on Materials Policy 'Material Needs and the Environment: Today and Tomorrow,' 93rd Cong., 1st sess., 1973, p. 1.

[6]Ibid., p. 13.

[7]Ibid., pp. 15-16.

[8]U. S., Congress, Public Law 91-631, Mining and Minerals Policy Act of 1970, 91st Cong., 31 December 1970. Statutes, 84: 1986.

[9]Congress, Hearings, Final Report of the National Commission on Materials Policy, p. 13.

[10]Congress, Mining and Minerals Policy Act of 1970, 84: 1876.

[11]See U. S., Comptroller General, Report to Congress: Need to Develop a National Non-Fuel Minerals Policy (2 July 1976); and U. S., Congress, Congressional Budget Office, U. S. Raw Materials Policy: Problems and Possible Solutions, Background Paper No. 16 (28 December 1976).

[12]Comptroller, Need to Develop, p. 3.

[13]Ibid., p. i.

[14]Ibid., p. 3.

[15]Ibid., pp. 9-11.

[16]Most of these conflicts appear to be in the areas of environmental protection and availability of Federal land for mineral development, as discussed in U. S., Department of the Interior, Annual Report of the Secretary of the Interior Under the Mining and Minerals Act of 1970 for 1977, pp. 65-116.

[17]Interior, Annual Report of Secretary for 1977, pp. 25-26.

[18]Congressional Budget Office, U. S. Raw Material Policy, pp. 9-12.

[19]For a discussion of the mechanism to limit producer's ability to sustain such action see Chapter II above.

[20]See Congressional Budget Office, U. S. Raw Materials Policy, p. 18; and U. S., Executive Office of the President, Council on International Economic Policy, Special Report: Critical Imported Materials (December 1974), p. 44.

[21]Congressional Budget Office, U. S. Raw Materials Policy, pp. 13-21.

[22]See Philip Connelly and Robert Perlman, The Politics of Scarcity: Resource Conflicts in International Relations (London: Oxford University Press for the Royal Institute of International Affairs, 1975), pp. 100-102; Raymond Mikesell, Non-Fuel Minerals: U. S. Investment Policy Abroad, The Washington Papers Vol. 3, No. 23 (Beverly Hills: Sage Publication, 1975), p. 83; Sanford Rose, "Third World 'Commodity Power' Is a Costly Illusion," Fortune (November 1976): 147, 160; John E. Tilton, The Future of Nonfuel Minerals (Washington, D. C.: The Brookings Institution, 1977), p. 101; and Congressional Budget Office, U. S. Raw Materials Policy, pp. 41-48.

[23]The National Commission on Supplies and Shortages was created by Public Law 93-426 in 1974 to address the areas of resource exhaustion, import dependence, adequacy of Federal mechanism dealing with materials, problems, and market mechanisms and shortages.

[24]See Tilton, The Future, p. 99; U. S., Congress, National Commission on Supplies and Shortages, Government and the Nation's Resources (1976), p. 39; Congressional Budget Office, U. S. Raw Materials Policy, p. 36; and Secretary of the Interior, Annual Report for 1977, p. 27.

[25]Commission on Supplies, Government and Resources, p. 134.

[26]See Tilton, The Future, pp. 95-99; and Commission on Supplies, Government and Resources, pp. 138-140.

[27]Tilton, The Future, p. 97.

[28]Congressional Budget Office, U. S. Raw Materials Policy, pp. 39-40.

[29]See Commission on Supplies, Government and Resources, pp. 138-139; and Congressional Budget Office U. S. Raw Materials Policy, p. 39.

[30]A detailed study on economic stocking is in U. S., Congress, National Commission on Supplies and Shortages, Studies on Economic Stockpiling, by Richard J. Barber Associates, Inc., and Charles River Associates (Washington, D. C.: Government Printing Office, 1976).

[31]Commission on Supplies, Government and Resources, p. 140.

CHAPTER V

CONCLUSION

Summary of Findings

The United States import reliance on non-fuel minerals is high (see Figure 2). For the case study minerals, the 1977 reliances were: chromium, 92 percent; cobalt, 97 percent; manganese, 98 percent; nickel, 70 percent; and platinum-group metals, 92 percent.[1] The trends of these minerals for the period 1950 to 1977 indicate an historically high import reliance. Generally, there has been a slight increase in reliances, but they appear to have stabilized in the 1970s at current levels.

The importance of each of these minerals to United States industry and the Nation's economy must be stressed, together with their strategic value. The outlook for the near future indicates that nickel is the only likely candidate for substitution, but the consequences of costs and the use of possible alternates that are also considered critical industrial materials are discouraging. Chromium and manganese probably are the worst cases with no reasonable promise of substitutes for their major essential uses. Technological advances will moderate the quantities required for these minerals, but any savings will most likely be offset by a growing demand.

Although the United States is endowed with vast natural resources, there are no significant domestic reserves of these minerals. The Nation's resources of chromium, cobalt, manganese, and platinum-group metals are of low-grade quality and are not currently economically competitive with foreign sources. Domestic manganese deposits are of such low grade that they are not considered for development except under emergency. The only mineral for which domestic primary production has been a reasonable component of supply is nickel, but demand will most likely deplete these reserves before 2000. World reserves have been found to be more than adequate in each case to meet the forecast demand of the United States and the rest of the world. The ratios for recoverable reserves to cumulative demand to the year 2000 is: chromium, 5.7; cobalt, 2.1; manganese, 4.9; nickel, 2.1; and platinum-group metals, 2.8.

The projected growth rates of demand to the year 2000 for the rest of the world are higher than those of the United States. This will probably result in increasing competition among consuming countries for the world's resources. The substantial difference between the increasing rate of world mineral consumption and United States consumption rate is shown in Figure 16. This stems from the widespread industrial growth in Western Europe and

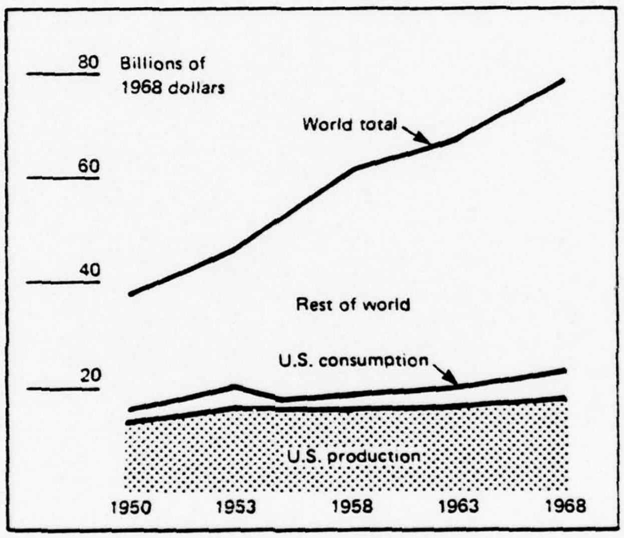

Figure 16

World Mineral Consumption versus U. S. Consumption Rate

SOURCE: U. S., Department of the Interior, Bureau of Mines, Draft of Strategic and Tactical Plan (January 1976), p. II-9.

Japan, while at the same time less developed countries are beginning to experience industrialization and the economies of the centrally planned countries are expanding.

There was no evidence of violent price fluctuations for the case study minerals. The representative prices of chromium and manganese had shown a decline over the 1960s, but worldwide demand and inflationary pressures increased the prices in 1974, with that trend continuing throughout 1977. Cobalt prices, however, have shown a steady increase over the past two decades. Platinum-group metals have experienced relative price stability as had nickel, until the 1969 Canadian nickel mining strike spurred its price upward. High demand for these minerals coupled with the rising costs of energy and inflation will probably continue to pressure their prices slightly upward.

The potential for cartel-like actions to restrict supplies or raise prices was found to be unlikely with the case study minerals for reasons of impractical partnerships or the demonstrated willingness or need to trade. Additionally, there are many factors that limit such actions. However, caution still should be exercised in the cases of chromium, cobalt, and platinum-group metals. Although a demonstrated potential does not exist, the mechanisms to make it possible do exist. These minerals are highly concentrated in countries that may have different political ideologies among themselves, but a common target

with greatly differing views from theirs could serve as a bond for an otherwise unlikely group.

The relative import values by source are shown in Table 15. This serves to emphasize several relevant findings. One is that these non-fuel minerals represent a rather significant dollar value to add to the negative side of the Nation's balance of payments. Although this situation appears undesirable, it is less costly, compared to domestic production. Conversely, the economic value to the producing country for its export trade with the United States for these minerals is also shown. Finally, the relative value between the imports of ores and metals for chromium and manganese is shown. The newly established trend is for an increasing proportion of metal to ore, further increasing import costs.[2]

Recommendations

The immediate problems with non-fuel minerals supply appears to be the short-run imbalances between supply and demand and the rapid price fluctuations.[3] Current United States minerals policy is incapable of rectifying the problem.[4] Considerable efforts are being made to formulate a more comprehensive policy. Economic stockpiling is recommended as one of the most likely solutions. Properly managed, such a policy could guard against sudden and large disruptions in supply, combat potential or actual price manipulations by cartels or monopolists, or stabilize

Table 15

Relative Import Values by Source, 1972-75[1]

percentage
[million dollars]

Source	Chromium (33.8) Ore	Chromium (55.3) Metal	Cobalt (54.2) Metal	Manganese (45.1) Ore	Manganese (88.4) Metal	Nickel (699.2) Metal	Platinum Group (632.0) Metal	Value (1608.0)
Canada						64 (477.5)		(477.5)
Republic of South Africa	27 (9.1)	35 (19.4)		9 (4.0)	35 (30.9)		25 (158.0)	(221.4)
U.S.S.R.	31 (10.5)						31 (196.0)	(206.5)
United Kingdom							26 (164.3)	(164.3)
Norway			7 (3.8)			8 (55.9)		(59.7)
New Caledonia						7 (48.9)		(48.9)
Dominican Republic						6 (42.0)		(42.0)

Table 15 (continued)

Source	Chromium (33.8) Ore	Chromium (55.3) Metal	Cobalt (54.2) Metal	Manganese (45.1) Ore	Manganese (88.4) Metal	Nickel (699.2) Metal	Platinum Group (632.0) Metal	Value (1608.0)
France					38 (33.6)			(33.6)
Zaire			47 (25.5)					(25.5)
Japan	15 (8.3)				10 (8.8)			(17.1)
Brazil				36 (16.2)				(16.2)
Gabon				31 (14.0)				(14.0)
S. Rhodesia		25 (13.8)						(13.8)
Philippines	18 (6.0)							(6.0)
Australia				10 (4.5)				(4.5)

Table 15 (continued)

Source	Chromium (33.8) Ore	Chromium (55.3) Metal	Cobalt (54.2) Metal	Manganese (45.1) Ore	Manganese (88.4) Metal	Nickel (699.2) Metal	Platinum Group (632.0) Metal	Value (1608.0)
Finland			8 (4.3)					(4.3)
Turkey	12 (4.0)							(4.0)

[1]Percentages are for 1972-75 average. Import values are based on 1974 import figures and 1972-75 average percentages.

SOURCE: Data compiled from U. S., Department of the Interior, Bureau of Mines, Commodity Data Summaries 1977, pp. 34, 42, 98, 112, 126; and Minerals Year Book, vol. 1: Metals, Minerals, and Fuels, 1974 (1976), 307, 436, 789, 904, 1091.

mineral prices. Insurance against these problems would also provide the proper climate for long-term investments in mineral industries.

The long-run problems of mineral supplies are not to be ignored. Exploration for new deposits and the expansion of production facilities must be made now in order to meet future demand. Research and development must be a continuing effort in order to find substitutes, to reduce quantities of the mineral required, and to develop economical methods for the production of low-grade deposits. The search for new sources should be unending. There is a potentially vast resource contained in deepsea nodules, therefore the many questions surrounding this issue cannot be left unanswered for long.[3]

The world is not running out of non-fuel minerals.[6] Artificial shortages can be created by short-run supply interruptions, as a result of complex political and economic factors. As the economies of the world expand and diversify, interdependency becomes more apparent. Cooperation and mutual planning on an international scale could go a long way in eliminating mineral shortages and insuring the security of supplies at reasonable prices to all the people of the world.[7]

FOOTNOTES

[1]For a detailed discussion on these minerals, see Chapter III above.

[2]This trend was established for other metals in Roger Prestwich, "America's Dependence on the World's Metal Resources: Shifts in Import Emphasis, 1960-1970," Institute of British Geographers Transactions 64 (March 1975): 97-118.

[3]For a detailed discussion see Chapter II above.

[4]For a detailed discussion see Chapter IV above.

[5]U. S., Department of the Interior, Annual Report of the Secretary of the Interior Under the Mining and Minerals Policy Act of 1970 for 1976, pp. 116-118.

[6]See British-North American Committee, Mineral Development in the Eighties: Prospects and Problems (Washington, D. C.: British-North American Committee, 1976), p. 24; U. S., Congress, National Commission on Supplies and Shortages, Government and the Nation's Resources (1976), p. 3.

[7]See John E. Tilton, The Future of Nonfuel Minerals (Washington, D. C.: The Brookings Institution, 1977), p. 107; and U. S., Department of State, "Sharing the World's Natural Resources: Prospects for International Cooperation," The Department of State Bulletin 75 (30 August 1976): 294-99.

GLOSSARY

GLOSSARY OF RESOURCE TERMS[1]

RESOURCE. - A concentration of naturally occurring solid, liquid, or gaseous materials in or on the Earth's crust in such form that economic extraction of a commodity is currently or potentially feasible.

IDENTIFIED RESOURCES. - Specific bodies of mineral-bearing material whose location, quality, and quantity are known from geologicl evidence supported by engineering measurements with respect to the demonstrated category.

UNDISCOVERED RESOURCES. - Unspecified bodies of mineral-bearing material surmised to exist on the basis of broad geologic knowledge and theory.

RESERVE. - That portion of the identified resource from which a usable mineral and energy commodity can be economically and legally extracted at the time of determination. The term *ore* is used for reserves of some minerals.

The following definitions for measured, indicated, and inferred are applicable to both the Reserve and Identified-Subeconomic resource components.

MEASURED. - Reserves or resources for which tonnage is computed from dimensions revealed in outcrops, trenches, workings, and drill holes and for which the grade is computed from the results of detailed sampling. The sites for inspection, sampling, and measurement are spaced so closely and the geologic character is so well defined that size, shape, and mineral content are well established. The computed tonnage and grade are judged to be accurate within limits which are stated, and no such limit is judged to be different from the computed tonnage or grade by more than 20 percent.

INDICATED. - Reserves or resources for which tonnage and grade are computed partly from specific measurements, samples, or production data and partly from projection for a reasonable distance on geologic evidence. The sites available for inspection, measurement, and sampling are too widely or otherwise inappropriately spaced to permit the mineral bodies to be outlined completely or the grade established throughout.

DEMONSTRATED. - A collective term for the sum of measured and indicated reserves or resources.

INFERRED. - Reserves or resources for which quantitative estimates are based largely on broad knowledge of the geologic character of the deposit and for which there are few, if any, samples or measurements. The estimates are based on an assumed continuity or repetition, of which there is geologic evidence; this evidence may include comparison with deposits of similar type. Bodies that are completely concealed may be included if there is specific geologic evidence of their presence. Estimates of inferred reserves or resources should include a statement of the specific limits within which the inferred material may lie.

IDENTIFIED-SUBECONOMIC. - Resources that are not Reserves, but may become so as a result of changes in economic and legal conditions.

PARAMARGINAL. - The portion of Subeconomic Resources that (1) borders on being economically producible or (2) is not commercially available solely because of legal or political circumstances.

SUBMARGINAL. - The portion of Subeconomic Resources which would require a substantially higher price (more than 1.5 times the price at the time of determination) or a major cost-reducing advance in technology.

HYPOTHETICAL RESOURCES. - Undiscovered resources that may reasonably be expected to exist in a known mining district under known geologic conditions. Exploration that confirms their existence and reveals quantity and quality will permit their reclassification as a Reserve or Identified-Subeconomic resource.

SPECULATIVE RESOURCES. - Undiscovered resources that may occur either in known types of deposits in a favorable geologic setting where no discoveries have been made, or in as yet unknown types of deposits that remain to be recognized. Exploration that confirms their existence and reveals

quantity and quality will permit their reclassification as Reserves or Identified-Subeconomic resources.

SOURCE: [1]U. S., Department of the Interior, Bureau of Mines, Mineral Facts and Problems, Bulletin 667 (1976), pp. 16-17.

BIBLIOGRAPHY

British-North American Committee. Mineral Development in the Eighties: Prospects and Problems. Washington, D. C.: British-North American Committee, 1976.

Brubaker, Sterling. In Command of Tomorrow: Resource and Environmental Strategies for Americans. Baltimore: The Johns Hopkins University Press for Resources for the Future, Inc., 1975.

Cameron, Eugene N., ed. The Mineral Position of the U. S., 1975-2000. Madison: University of Wisconsin Press, 1973.

Clarfield, Kenneth W.; Jackson, Stuart; Keeffe, Jeff; Nobel, Michaele Ann; and Ryan, A. Patrick. Eight Mineral Cartels: The New Challenge to Industrial Nations. McGraw-Hill Publications Company, 1975.

Connelly, Phillip, and Perlman, Robert. The Politics of Scarcity: Resource Conflicts in International Relations. London: Oxford University Press for The Royal Institute of International Affairs, 1975.

Dickson, Robert, and Rogers, Paul. "Resources, Producer Power and International Relations." In Future Resources and World Development, pp. 77-100. Edited by Paul Rogers. New York: Plenum Press, 1976.

Hammond, Allen L. "Manganese Nodules (II): Prospects for Deep Sea Mining." Science (15 February 1974): 644-646.

McAuley, Robert. "The Scramble for Resources." Business Week (30 June 1973): 56-63.

Marsden, Ralph W., ed. Politics, Minerals, and Survival. Madison: University of Wisconsin Press, 1975.

Mikdashi, Zuhayr. The International Politics of Natural Resources. Ithaca: Cornell University Press, 1976.

Mikesell, Raymond F. Non-Fuel Minerals: U. S. Investment Policy Abroad. The Washington Papers Vol. 3, No. 23. Beverly Hills: Sage Publications, 1975.

Miller, Roger LeRoy. The Economic Impact of U. S. Restrictions on Trade With Rhodesia. Coral Gables, Florida: University of Miami, 1974.

Morton, Rogers C. B. "A Minerals Crisis Would Be Worse Than the Energy Crisis." Forbes (15 February 1974): 48-49.

Novick, David. A World of Scarcities: Critical Issues in Public Policy. New York: Halsted Press, John Wiley and Sons, 1976.

Prestwich, Roger. "America's Dependence on the World's Metal Resources: Shifts in Import Emphases, 1960-70." Institute of British Geographers Transactions 64 (March 1975): 97-118.

Rogers, Paul, ed. Future Resources and World Development. New York: Plenum Press, 1976.

Rose, Sanford. "Third World 'Commodity Power' Is A Costly Illusion." Fortune (November 1976): 147-60.

Sutulov, Alexander. Minerals in World Affairs. Salt Lake City: University of Utah Printing Services, 1972.

Tilton, John E. The Future of Nonfuel Minerals. Washington, D. C.: The Brookings Institution, 1977.

Varon, Bension, and Takeuchi, Kenji. "Developing Countries and Non-Fuel Minerals." Foreign Affairs 52 (April 1974): 497-510.

Wu, Yuan-li. Raw Material Supply In A Multipolar World. New York: Crane, Russak and Company, 1973.

U. S. Army War College. Strategic Studies Institute. Materials and the New Dimensions of Conflict. revised ed., by Alwyn H. King and John R. Cameron. Military Issues Research Memorandum 74-10-R. Carlisle Barracks, PA: U. S. Army War College, 1974.

U. S. Army War College. Strategic Studies Institute. Materials Vulnerability of the United States - An Update, by Alwyn H. King. Special Report ACN 77020. Carlisle Barracks, PA: U. S. Army War College, 1977.

U. S. Comptroller General. Report to Congress: Need to Develop a National Non-Fuel Minerals Policy (2 July 1976).

U. S. Congress. Congressional Budget Office. U. S. Raw Materials Policy: Problems and Possible Solutions. Background Paper No. 16, 28 December 1976.

U. S. Congress. National Commission on Supplies and Shortages. Government and the Nation's Resources, 1976.

U. S. Congress. National Commission on Supplies and Shortages. Studies on Economic Stockpiling, by Richard J. Barber Associates, Inc., and Charles River Associates. Washington, D. C.: Government Printing Office, 1976.

U. S. Congress. Public Law 91-512. National Materials Policy Act of 1970. 91st Cong., 26 October 1970. Statutes, 84:1234-36.

U. S. Congress. Public Law 19-631. Mining and Minerals Policy Act of 1970. 91st Cong., 31 December 1970. Statutes, 84:1876.

U. S. Congress. Senate. Committee on Interior Insular Affairs. Hearings before a Subcommittee on Minerals, Materials, and Fuels. The Final Report of the National Commission on Materials Policy 'Material Needs and the Environment: Today and Tomorrow.' 93rd Cong., 1st sess., 1973.

U. S. Department of Commerce. Bureau of Census and U. S. Department of the Interior. Bureau of Mines. Raw Materials in the U. S. Economy: 1900-1969, by Vivian Eberle Spencer. Working Paper 35. Washington, D. C.: Government Printing Office, 1972.

U. S. Department of the Interior. Annual Report of the Secretary of the Interior Under the Mining and Minerals Act of 1970 for 1976.

U. S. Department of the Interior. Annual Report of the Secretary of the Interior Under the Mining and Minerals Policy Act of 1970 for 1977.

U. S. Department of the Interior. Bureau of Mines. Chromium-1977, by John L. Morning. Mineral Commodity Profiles. MCP-1. Washington, D. C.:

Government Printing Office, 1977.

U. S. Department of the Interior. Bureau of Mines. Cobalt-77, by Scott F. Sibley. Mineral Commodity Profiles. MCP-5. Washington, D. C.: Government Printing Office, 1977.

U. S. Department of the Interior. Bureau of Mines, *Commodity Data Summaries 1977*.

U. S. Department of the Interior. Bureau of Mines. Draft of Strategic and Tactical Plan (January 1976).

U. S. Department of the Interior. Bureau of Mines. Manganese-77, by Gilbert L. DeHuff. Mineral Commodity Profiles. MCP-7. Washington, D. C.: Government Printing Office, 1977.

U. S. Department of the Interior. Bureau of Mines. Mineral Facts and Problems. Bulletin 667, 1976.

U. S. Department of the Interior. Bureau of Mines. Mineral Forecasts and Trends (1976).

U. S. Department of the Interior. Bureau of Mines. Mineral Industries of Africa (1976).

U. S. Department of the Interior. Bureau of Mines. Minerals and Materials/A Monthly Survey (June 1977).

U. S. Department of the Interior. Bureau of Mines. Minerals and Materials/A Monthly Survey (December 1977).

U. S. Department of the Interior. Bureau of Mines. Minerals and Materials/A Monthly Survey (January 1978).

U. S. Department of the Interior. Bureau of Mines. Minerals in the U. S. Economy: Ten-Year Supply-Demand Profiles for Mineral and Fuel Commodities (1966-75).

U. S. Department of the Interior. Bureau of Mines. Minerals Yearbook, 1974, Vol. 1: Metals, Minerals and Fuels (1976).

U. S. Department of the Interior. Bureau of Mines. Nickel-77, by John D. Corrick. Mineral Commodity Profiles. MCP-4. Washington, D. C.: Government Printing Office, 1977.

U. S. Department of the Interior. Bureau of Mines. Platinum-Group Metals, by W. C. Butterman. Preprint from Bulletin 667. Mineral Facts and Problems. Washington, D. C.: Government Printing Office, 1975.

U. S. Department of State. "Sharing the World's Natural Resources: Prospects for International Cooperation." The Department of State Bulletin 75 (30 August 1976): 294-99.

U. S. Executive Office of The President. Council on International Economic Policy. Special Report: Critical Imported Materials. December 1974.

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